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The current state of military understanding is in crisis, resulting from the application of a linear thought process to dynamic, complex problems. The crisis does not originate in a lack of creativity. To the contrary, the crisis lies in an unfounded faith in the innate creative ability of the commander and his staff. This faith manifests in the joint doctrinal characterization of operational art as creative imagination, which in practice has become a vacuous panacea for complex problems. Lines of thought that do not fit the desired cognitive order are discarded as a product of chance and uncertainty in favor of a more palatable narrative. The current concept of joint operational art must change. Developing a nonlinear analytical method will eliminate the "inshallah" approach to understanding complexity, defragment and restore a stable doctrinal foundation, and establish postulates for understanding the operational environment.

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JOINT FORCES STAFF COLLEGE

JOINT ADVANCED WARFIGHTING SCHOOL

THE OPERATIONAL CALCULUS: IT'S NOT ART

by

Michael McRoberts

Department of Defense Civilian

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A paper submitted to the Faculty of the Joint Advanced Warfighting School in partial satisfaction of the requirements of a Master of Science Degree in Joint Campaign Planning and Strategy. The contents of this paper reflect my own personal views and are not necessarily endorsed by the Joint Forces Staff College or the Department of Defense.

This paper is entirely my own work except as documented in footnotes.

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1 March 2012

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ABSTRACT

The current state of military understanding is in crisis resulting from the application of a linear thought process to dynamic, complex problems. The crisis does not originate in a lack of creativity. To the contrary, the crisis lies in an unfounded faith in the innate creative ability of the commander and his staff. This faith manifests in the joint doctrinal characterization of operational art as creative imagination, which in practice has become a vacuous panacea for complex problems. Lines of thought that do not fit the desired cognitive order are discarded as a product of chance and uncertainty in favor of a more palatable narrative. The current concept of joint operational art must change.

Developing a nonlinear analytical method will eliminate the "inshallah" approach to understanding complexity, defragment and restore a stable doctrinal foundation, and establish postulates for understanding the operational environment. A new principle of mass applicable in both the physical and metaphysical realms is the key linkage to a new fundamental theorem of operational art. With mass, force becomes a function of time that describes the motion of order and chaos spanning the tactical to the strategic levels.

ACKNOWLEDGEMENTS

My unbridled gratitude goes out to my wife. You have been a single parent more times than not in our marriage as I have chased wars and schools. Any success I am fortunate enough to achieve belongs to you.

This thesis emerged from the ideological domain of Seminar II. I hope this work does justice to the collective cognition that exists outside any one of us.

DEDICATION

To my son, whose insatiable stream of "Hey Dad, why?" made me think.
To my daughter, whose bold creativity and confident imagination made me blink.

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INTRODUCTION

"We will not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time." – T.S. Elliot

The current state of military understanding is in crisis. This crisis does not originate in a lack of creativity. To the contrary, the crisis lies in an unfounded faith in the innate creative ability of the commander and his staff. Given the current state of joint doctrine, and the lack of coherent theory to support the doctrine, the military thinker, when challenged to exhaustion intellectually and conceptually, makes a cognitive leap to the panacea of creative, imaginative operational art. Art is not a concept that can explain; art expresses, and therefore applies equally to chaotic solutions as it does to orderly solutions. The indoctrination of this type of operational art offers an escape route from the difficult cognitive journey to make sense of complexity, inventing more palatable perceptions along the way.

A new principle of mass applicable in both the physical and ideological realms is the key linkage to a new fundamental theorem of operational art. Mass, understood as *the characteristics of a body that resist change,* allows force to be written as a function of time describing the motion of order and chaos spanning the tactical to the strategic levels. Far from linear, the force function considers myriad, but not infinite, trajectories. The behavior of the function determining the next state of the environment, physical and metaphysical, follows a set of universal postulates.

This thesis argues the fundamental need to change the aforementioned doctrinal terms of operational art and the principle of mass. More importantly, in arguing why those terms should be changed and investigating the historical origins of the crisis in military understanding, this thesis offers a new way of thinking to deal with rapid change.

In contrast to the nonlinear thinking required of today's operational practitioner, military doctrine has become cluttered with terms like nonlinear, chaotic, uncertain, and ambiguous in attempts to reconcile the contradiction in cognitive models created by a linear framing of a complex and constantly changing environment. Collective awareness of the overwhelming complexity of an ever-shifting interplay of forces is not novel, though, as the security establishment has recognized for some time the dire need for critical thinkers who understand dynamic, complex problems. Indeed, wholesale efforts have been made to create critical thinkers within the military. However, critical thinking in many cases simply results in a greater quantity of the same quality of thought, not different thought. The product is more thinking, not better thinking. In an era of frequent, accelerating change, there is no time in the decision-making cycle to waste on more of the same.

Critical thinking, in the current paradigm of military affairs, is the point in study where the number of cognitive linear segments becomes a complex web of intersections and areas defined by observations. It is at this critical juncture where instead of developing a thought process to order complexity, the military thinker is encouraged, counterintuitively, to rely on organic creativity and inherent cognitive capability behind the mental curtain of fog and friction. Lines of thought that do not fit the desired order are discarded as a product of chance and uncertainty in order to develop a more palatable narrative. Precise solutions that emerge from cognition are attributed to the *coup d'oeil* of the commander--the inexplicable genius of a Napoleon, Lee, or Patton.[1] This brand of

[1] Carl von Clausewitz, *On War,* ed. and trans. by Michael Howard and Peter Paret, (Princeton, NJ: Princeton University Press, 1976), 578. Clausewitz uses *coup d'oeil* synonymous with commander's intuition or "to identify the whole business of war completely within himself."

operational art, while naïve in description, is an attempt to understand the mental calculus that is naturally undertaken when the human mind is forced to make complex decisions. It is not art, but calculus.

Practitioners of the operational art will make the case that the subtleties, nuances, and context of doctrinal operational art preclude any dangers of dogmatic belief in the infallibility of doctrine. Part I of this paper presents the argument that it is precisely the danger inherent in subtlety, nuance, and context that threaten to explain away any semblance of complex understanding. Subtle interpretation within the context of a nuanced environment lures the thinker into believing that any and all creative solutions lay within the realm of the possible and the scope of the acceptable. When continued contradictions befuddle further exploration, one is left with the "inshallah" approach--a *faith* or *hope* that the environment will unfold in the way one wishes.[2]

The current cognitive crisis originated primarily with the theories put forth by Jomini and Clausewitz to explain Napoleonic warfare. Repulsed by the prescriptive, geometric doctrine of the previous century, the theorists set out to prove that war was art, not science.[3] The antithesis presented to eighteenth century Euclidean geometric methods was the trinity of violence, chance, and reason. These observations on the nature of war were true; however, they did not present a framework that could lead to understanding of a nonlinear, dynamic environment. The mechanical metaphors that

[2] Inshallah, loosely translated from Arabic, means "God willing." In this context it is used to imply the end of critical thinking actively seeking understanding in deference to the simpler solution of faith or hope.

[3] Baron Antoine Henri de Jomini, *The Art of War,* intro. by Charles Messenger (London: Greenhill Books, 1992), vi. Messenger noted that Jomini and Clausewitz intended to prove that war was an art, not a science.

became intrinsic to a Clausewitzian theory of war ignored the cognitive method Newton developed to frame the concepts of mechanics.

The 1976 Peter Paret and Michael Howard translation of *On* War transposed the nineteenth-century work of Clausewitz onto the script of a post-Vietnam Army establishment seeking understanding.[4] The underlying conditions and fragmented ideas that gave birth to Clausewitzian theory were again present as a weary military establishment limped out of a quagmire in Southeast Asia. It was not just the metaphors of Clausewitz that were reborn in the twentieth century; it was an entire way of thinking. The timing and conditions were perfect for the theory to dominate in the debates that would shape the military leaders of the twenty-first century.

The key tenets of Army doctrine in the post-Vietnam era, shaped by Clausewitzian theory, made their way into the patchwork of joint doctrine in time for the wars in Iraq and Afghanistan. When the contradictions of two protracted insurgencies overwhelmed the applicability of a fragmented doctrine, the establishment pushed further away from cognitive order and coined a new definition of operational art in the 2006 revision of Joint Publication 3-0. Instead of the traditional view of military art as the skillful application of a trade only achieved through years of study and practice, art became an imaginative way of thinking.[5] Art was the genius of the man who could make whole the set of fragmented observations. The cognitive crisis was set.

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[4] Clausewitz, *On War*.

[5] Joint Staff, *Joint Publication 3-0: Joint Operations* (Washington, DC:US Department of Defense, 2011), I-5. "Operational art, the creative thinking used to design strategies, campaigns, and major operations and to organize and employ military force, allows commanders to better understand the challenges facing them and to conceptualize an approach for achieving their strategic objectives. The thought process helps commanders and their staffs to lessen the ambiguity and uncertainty of a complex operational environment." See also Appendix B: The Panacea of Operational Art.

The thread of a mathematical model of temporal cognitive development of increasing complexity begins in Part I of this thesis and continues throughout. The cognitive model is framed with Euclidean geometric methods to the point where trillions of cognitive line segments are changing every instant in a world where complex environments merge through globalization. The military mindset pushes onward with archaic Euclidean methods, and in pursuit of greater clarity and precision draws another line segment to order the uncertainty. The process repeats as the realization sets in that with each new line segment drawn to order the environment, the complexity grows and more uncertainty appears. When the model can no longer host an understanding of each data point and line segment that make up the whole, a cognitive blink is required to see the world in a different way--the way Newton and Leibniz prescribed to understand continuous change.

The continuous change of the ever-competing forces of creation and destruction becomes the nonlinear motion of a collective cognition balancing order and chaos; that nonlinear path is the essence of complexity. Contrary to a chaotic theory of the universe, complexity is the substance of physical or metaphysical bodies that emerges at the transition of order and disorder. The practitioners of the military art who operate closer to the edge of chaos likely subscribe to an unpredictable nature of war--and rightly so. They see the seemingly unpredictable destruction more than the ordered creation. It is not wholly unpredictable, though, as there are a finite number of potential outcomes given an initial state and a set of logical, evolutionary rules to follow.

Far from mechanistic, the changing nature of the environment is not understood with a formula. It is a way of thinking. The Operational Calculus--Part II of this work--

puts forth a method to make sense of the infinite and the infinitesimal of change. Constant change happens in infinitesimally small increments of time. The whole of change can only be understood through an infinite number of these increments at each moment. A flipbook of change flows into a motion picture of change only through nonlinear intuitive cognition, not by drawing more line segments on a single page.

Often the failure of intuitive cognition is the inability to perceive that motion in the physical environment is the same as motion in the metaphysical environment. Motion is change in position, and the rate of change is nonlinear. It is not an additive system: the parts do not sum to the whole and the change is not proportional. Dynamic complexity, a complicated environment with numerous functions, is just as relevant to describing the movement of a tank as it is to describing a social revolution. The metaphysical and physical converge through a holistic concept of mass as a resistance to change. Mass, though a principle of joint operations, has no joint doctrinal definition, only a description that differs little from the concept of concentration.

Contrary to a common understanding of mass, even the mass of a physical body, mass is more than "a bunch of something." Mass is the manifold characteristics of a body that allow it to resist change—a measure of its inertia. Undoubtedly, for the purpose of applying operational calculus to the military element of national power, there is a concept of mass required distinct from concentration. Mass is a necessary component in understanding both the physical dimension of war and the metaphysical, or ideological, dimension of war. Ideological mass is key to the force equation describing the outlay of national power, military and other, required to produce a desired change in the environment. Ideological mass is also a critical requirement to understand conceptual momentum of ideas in military operations whose complexity exceeds that of the physical movement of physical bodies. It was not the momentum of tanks and bombs that toppled governments throughout the Maghreb during the Arab Spring of 2011; it was a set of rapidly moving ideas capable of overcoming resistance to change. The addition of mass to the cognitive method opens up further avenues of exploration to deduce practical qualitative properties of the operational and strategic environments. These properties, viewed through the new mass, are the set of rules to reduce the predictive uncertainty of the next state of order and chaos in the operational environment.

Mass allows the pattern of change to be examined as the function of force over time, and, through the analytical method of operational calculus, a characteristic of energy forms to shape strategic choices. The time function of force leads to a rewrite of operational art as the Fundamental Theorem of Operational Calculus in Figure I-1 below. Each word in the revised definition has meaning derived from the content of this thesis, bringing clarity to the cognitive process underwriting the study of the operational level of war. There is no *hope* and *faith* that an "inshallah" moment will occur. There are accepted levels of certainty and uncertainty with the realization that perfect time and space cannot be understood just yet. However, the uncertainty is one rooted in a new method of cognitive understanding that transformed the physical world from the precision of spears to the precision of satellites. The potential to transform understanding of the ideological realm is limitless.

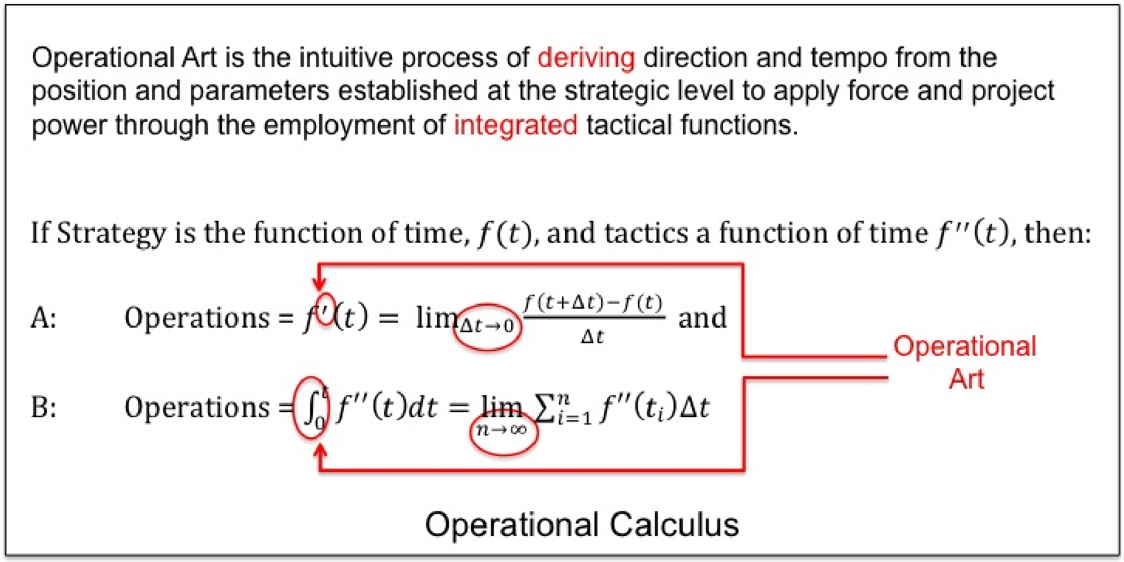

Figure I-1: The Fundamental Theorem[6]

The reader is encouraged to return to the Fundamental Theorem after the whole of this thesis is digested, as it is only through the establishment of common cognition that it can be understood in its entirety. This singular figure represents all of the concepts described in the pages that follow and many more. The figure represents an entire way of thinking--the way of thinking that allowed Newton to solve complex problems of constant change previously thought impossible. It is through this nonlinear methodology that today's dynamically complex environment will be understood.

In his "Discourse on Winning and Losing," Colonel John Boyd prefaced his adaptation of the second law of thermodynamics to the concept of rapid cognition with the acknowledgement that with any new discovery, the perception left at the end is very much dependent upon the path that is taken. Boyd said, "Yet, the theme that weaves its

[6] The Fundamental Theorem is explained in detail in Chapter 6 of this work. The mathematical notation represents the realization that decisions are made in a rapidly changing environment through the integration of a near infinite set of observations. There is no actual limit to how rapidly the environment can change, and therefore the time between changes in the environment is approaching, but never equal to zero. This figure, including the mathematical notation used, will be explained in detail in Chapters 5 and 6 of this work, but is presented here to begin shaping the cognition of the reader.

way through this 'Discourse on Winning and Losing' is not so much contained within each of the five sections, per se, that make up the 'Discourse'; rather, it is the kind of thinking that both lies behind and makes-up its very essence."[7] During the journey of this thesis, the reader will process billions of cognitive line segments and relate them to the existing set of cognitive data held in memory. The reader will store the entirety of this work in a very small cognitive area with a neat label on it for future reference. It will be used to refute, confirm, support, or create future states of order and chaos in cognition. The fundamental theorem, introduced here, may drastically alter the reader's cognitive order, it may simply better frame an area of understanding that already existed, or it may be used as a cognitive refutation to confirm an opposing view. In any event, the cognitive order will have changed, because it changes every instant, and the only way to understand it is with a new way of thinking.

[7] John Boyd, "A Discourse on Winning and Losing" (lecture, Airpower Australia Website), http://www.ausairpower.net/JRB/intro.pdf (accessed February 23, 2012).

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PART I: THE OLD WAY OF THINKING

Today's version of operational art has been in the making for several centuries--an evolutionary tension between the perspective of war as an art or war as a science. The story is one of an increasingly complex world contrasted against the military theorist's struggle to develop the cognitive tools to comprehend complexity. Since Napoleonic warfare shattered perceptions of the infallibility of geometric warfare, rarely has any sort of consensus in the military establishment supported the proposition of war as a science. Yet, the only alternative that has emerged as an antithesis to geometric warfare is a belief in the infallibility of creativity. Part I of the Operational Calculus describes the evolution of operational art from the time of Clausewitz to the arrival in 2006 of the "creative imagination" of the commander.

CHAPTER 1: THE GENESIS OF MODERN ART

Chapter 1 explores the nineteenth-century context in which Carl von Clausewitz's *On War* was written. The era marked the aftermath of Napoleonic warfare, and, as a result, the end of prescriptive geometric warfare of the previous century. Clausewitz, with his theory on the nature of war, intended to show that war was a complex undertaking wrought with uncertainty and chance, and could not be understood with a simple equation. This line of inquiry resulted in a terse antithesis to geometric principles; however, instead of building on the geometric principles to understand change, as Newton did, Clausewitz instead introduced the enduring premise that war was an unpredictable paradox in which violence was subordinated to reason.[1] Parallel to the historical development, Chapter 1 also begins a geometric build of complex cognition that carries through this thesis and grows in the number and relationships of cognitive line segments in parallel to the growth of the complexity of war. Somewhat ironically, the geometric build, in contrast to Clausewitz's refutation of geometric principles, becomes the foundation for a nonlinear cognitive method to reduce uncertainty in today's complex environment.

A Curious Species

In the beginning, Clausewitz created the trinity. To the military reader, this trinity is the well-known characterization of the nature of war as the interaction of violence, chance, and reason.[2] Of course, there was war and theory of war before Clausewitz; however, for the purposes of exploring the origins of the fragmented linear thought process that underpins current military doctrine, the early nineteenth century provides a useful starting point. Clausewitz began his journey toward a theory of war with the recognition that "the theories we presently possess . . . try so hard to make their systems coherent and complete that they are stuffed with commonplaces, truisms, and nonsense of every kind."[3] Ironically, the Clausewitzian trinity is partially responsible for a similar state of doctrine today.

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[1] Clausewitz, *On War,* 89.

[2] Ibid. The Howard and Paret translation of Clausewitz describes the trinity as "composed of primordial violence, hatred, and enmity, which are to be regarded as a blind natural force; of the play of chance and probability within which the creative spirit is free to roam; and of its element of subordination, as an instrument of policy, which makes it subject to reason alone."

[3] Ibid., 71.

The concepts of chance and uncertainty introduced by Clausewitz have been stuffed into cracks and crevices in military theory for the last three decades to the point where a comprehensive theory of war has devolved into an abyss of artistic ambiguity.[4] However, to renounce current doctrine is not equivalent to deriding the natural tendency to order one's environment; it is not a call for more nuance and less certainty in doctrine. On the contrary, the act of problem solving is organic to the human condition and a required step in evolutionary growth of any sort. "The human mind, moreover, has a universal thirst for clarity, and longs to feel itself part of an orderly scheme of things."[5] Even linear, algorithmic, or simplistic problem solving is acceptable for simplistic environments, but the strategic environment in which the military operates is not simplistic, not when Clausewitz wrote and certainly not today.

The work of another eighteenth-century Prussian, Immanuel Kant, is used to begin the parallel exploration of a linear thought methodology.[6] In his *Critique of Pure Reason,* published in 1781, Kant discusses at length the concept of knowledge "*a priori,*" Latin for "what comes before," to describe the concept of innate human cognition independent of experience.[7] Imagine a cognitive being with only *a priori* knowledge experiencing the first interaction with his environment. The first orientation to his

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[4] The Goldwater Nichols Act of 1986 established the statutory requirement for Joint Operations and can be seen as a milestone that catalyzed a host of changes in military theory and doctrine. The devolution will be discussed further below; See Appendix B: The Panacea of Operational Art for examples of how uncertainty has been answered in doctrine with creativity.

[5] Clausewitz, *On War,* 71.

[6] For a discussion of the influence of Kant on Clausewitz see Robert A. Pelligrini, "The Links Between Science and Philosophy and Military Theory: Understanding the Past, Implications for the Future" (US Air Force School of Advanced Airpower Studies Paper, Montgomery, AL,1997), http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA329077 (accessed January 21, 2012).

[7] Immanuel Kant, *Critique of Pure Reason,* trans. by J. M. D. Meiklejohn (Amherst, NY: Prometheus Books, 1990), 3.

environment, before further exploration, becomes an instant cognitive picture of his surroundings--a snapshot of all that is available to his senses. The first set of cognition is then the building block upon which all else is related.

For simplicity, the initial environment can be seen as a symmetrical extension of the senses in every direction from the point of the observer. If this extension of the senses is envisioned in a two-dimensional plane, the snapshot of the environment takes the shape of a circle with a radius equal to the limit of his senses. In a Darwinian sense, it would be counterintuitive for this species to remain static and not explore his environment as an intelligent creature set on survival. Indeed, Darwin observed, "Widely ranging species . . . will have the best chance of seizing on new places when they spread into new countries. In their new homes they will be exposed to new conditions, and will frequently undergo further modification and improvement, and thus they will become still further victorious."[8] The same applies to the cognitive domain. So, then, the natural inclination, spurred by an innate curiosity, is to embark on a logical, straight-line path toward the boundary of the environment, gaining insight along the way. These insights are stored as cognitive data points, adding to the *a priori* knowledge and the first set of cognition from the initial snapshot.[9]

Euclid described systematic straight-line exploration of the environment in the *Elements,* a voluminous treatise in which he compiled the vast knowledge of Greek

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[8] Charles Darwin, *Origin of the Species* (New York: Gramercy Books, 1979), 347.

[9] The geometrical exploration and framing used in this thesis will intentionally be described as symmetrical and proportional for simplicity. It is well recognized that little about human behavior is symmetrical or linear (proportional). Additionally, this thesis is intended to describe a qualitative analytical method. To research in-depth the psychology of cognition is beyond the scope of this paper; however, a recommended starting point for such exploration is John Locke, *An Essay on Human Understanding,* (Public Domain), http://www.gutenberg.org/ebooks/10615 (accessed 21 Jan 2012). For a brilliant modern application of the psychology of cognition, see Laurence Gonzalez, *Deep Survival* (New York: W.W. Norton & Company, 2005).

geometry into a comprehensive set of postulates in the third century BC "The general idea was to reformulate the hodge-podge of arithmetical results that had accumulated over the centuries into some kind of logical format."[10] This set of simple, but vast, arithmetic rules, otherwise known as Euclidean geometry, described with relative precision nonlinear measurements by utilizing increasingly complex polygons consisting of many line segments. The physical measurements are the equivalent to the metaphysical recordings taken along path of the *a priori* man as he systematically explores his environment. The data is recorded with manageable, known linear segments and stored as cognitive points, lines, and areas.

Figure 1-1 below starts with a single linear path and shows systematic exploration in a symmetrical process. At each point where the boundary is reached the destination becomes the center point of the next unknown area of the environment. The linear path of exploration frames the environment in a symmetrical polygon (square) and returns to the starting point. The resulting knowledge of the environment, neatly framed, provides a simplistic building block for further exploration, analysis, and synthesis. The cumulative knowledge is simply a summation of the known areas since linear functions are, by definition, additive. But, as illustrated in the First Order Knowledge below, the known environment clearly frames four distinct unknown areas, still within the original environment. The process of exploration is repeated, and it quickly becomes apparent that the number of paths to recall is increasing exponentially as greater precision is sought.[11]

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[10] Michael Guillen, *Bridges to Infinity* (Los Angeles: Jeremy P. Tarcher Inc., 1983), 14.

[11] The number of polygons is a function of the "ordering" of the environment, specifically equal to 2^n, where n represents the order as described in Figure 1. The number of line segments in the instance of a 4-sided polygon is equal to 2^{n+1}, and the number of unknown areas emerging in a linear framing is also

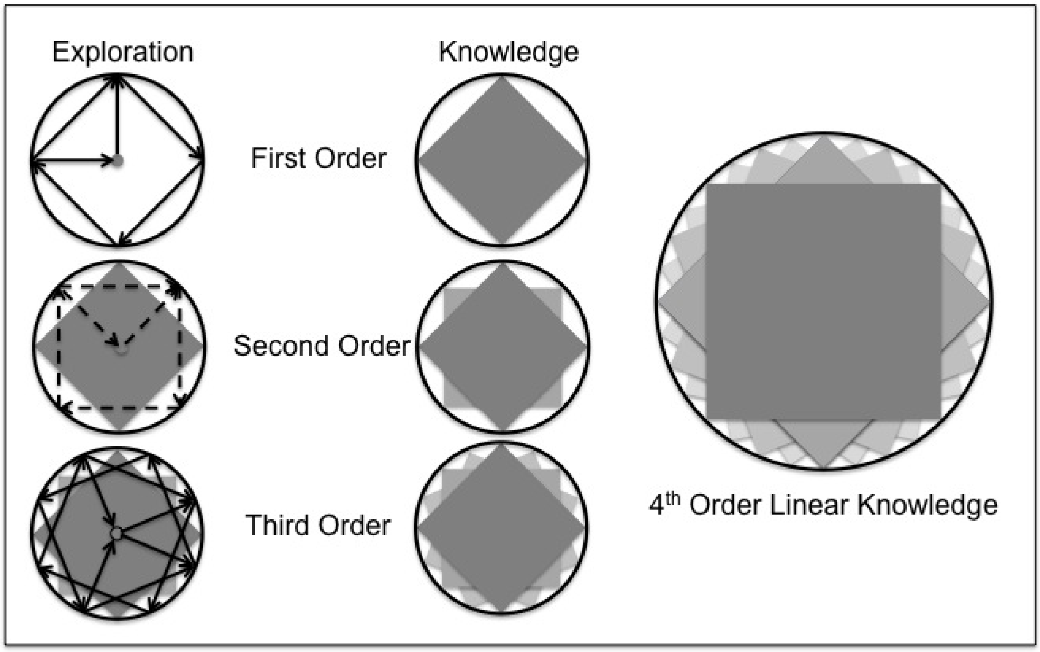

Figure 1-1: Linear Exploration[12]

The linear exploration illustration is employed not to review introductory geometry, but to demonstrate how quickly an environment increases in complexity with exponential growth. Human development is a well-documented process of autocatalytic growth--each successive development depends upon previous understanding.[13] Understood through the lens of aggregate and cumulative knowledge, learning and the accumulated knowledge that comes with it are exponential growth functions.[14] *A priori*

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equal to 2^{n+1} after the first order. The linear framing process is built to the point where it can no longer sustain sensible ordering and a new way of thinking is introduced.

[12] The first line segment used in this figure is the cognitive foundation for all that follows in this thesis. Three additional line segments form a square; the square is copied and rotated to better frame the environment until new environments emerge. Each successive figure builds complexity on this single line segment, just as the development of cognition builds upon cumulative knowledge. See also Figure C-1: Exploration in Appendix C.

[13] For a discussion of autocatalytic growth in human evolution see Chapter 13 of Jared Diamond, *Guns, Germs, and Steel*: *The Fates of Human Societies* (New York: W.W. Norton & Company, 1999), 239-264.

[14] The most widely known exponential information function is Moore's Law, which describes the growth in the storage capacity of digital media. The law was put forth by Intel co-founder Gordon Moore. See Intel's description of the law: Intel Corporation, "Moore's Law," (Copyright the Intel Corporation, 2005), ftp://download.intel.com/museum/Moores_Law/Printed_Materials/Moores_Law_2pg.pdf (accessed January 21, 2012).

man may have had no experiential knowledge to speak of, but his being was comprised of billions of intelligent cells, which had accumulated a form of exponential intelligent growth through millions of years of selection. He began his exploratory journey already as an intelligent creature.

Likewise, at the time of Clausewitz, the collective body of knowledge regarding the art of war was vast. Clausewitz's reordering of the body of knowledge is akin to Euclid's geometric elements--many of the postulates were well known for hundreds of years, but had never been consolidated and compiled. Clausewitz, as did Euclid, added his own observational elements to the collective: fog, friction, center of gravity, and others, many of which are critical components of today's doctrine.[15] In the process, Euclid's methods applied to warfare were abandoned; however, the method of Euclid's successor in physical measurement, Sir Isaac Newton, was not chosen as the foundation for a new theory of war.

Losing Euclid in the Fog of War

Mathematician Michael Guillen notes the origins of geometry in his essay *Nothing Like Common Sense:* "The geometry that would eventually be identified with Euclid originally came together in ancient Egypt as bits and pieces of practical knowledge . . . . The seminal ideas about points, lines, planes, and solids were shaped from common-sense ideas formed from experience."[16] The likeness, then, can be easily

[15] Joint Chiefs of Staff, *Doctrine for the Armed Forces of the United States: Joint Publication 1*, *Change 1* (Washington, DC: US Department of Defense, 2009), I-1. An example of the prominence of Clausewitz in today's doctrine is the fact that he is featured in the first substantive paragraph in JP-1, the capstone publication of the US joint doctrine hierarchy: "War is a complex, human undertaking that does not respond to deterministic rules; Clausewitz described it as "the continuation of politics by other means" [Book one, Chapter 1, Section 24 heading]."

[16] Guillen, *Bridges to Infinity*, 106.

recognized between the metaphorical *a priori* man exploring his environment and the actual cognitive development of ancient man. The growth of military theory and doctrine, or the cumulative knowledge of any collective body for that matter, has progressed in the same way--accumulated observations known to be true from experience are used to prove, disprove, or discover other truths.

The inseparability in societal advancement of mathematics, science, and war-fighting over the ages is well-described by Antoine Bousquet in *The Scientific Way of War*: "What men took to be fundamental truth about the nature of the world simultaneously became a powerful model for the organization of human affairs."[17] Bousquet discusses the common eighteenth-century perception of artillery, fortification, and siege tactics as an extension of elementary geometry, resulting in the belief that most functions of war could be readily understood with a few simple rules.[18] These presumptions, though, did not survive the revolution in military tactics and technology spurred by the Industrial Revolution, maneuver warfare, and the great mind of Napoleon Bonaparte.[19] By the early nineteenth century, Napoleonic warfare had fundamentally changed the nature and complexity of war.[20]

Military theorists were left with a set of deterministic geometric observations that no longer matched the complexity and uncertainty of war, and in reality hadn't matched for centuries. In his introduction to *The Art of War* by Baron Antoine Henri de Jomini,

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[17] Antoine Bousquet, *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity* (New York: Columbia University Press, 2009), 38.

[18] Ibid., 53-56.

[19] See Lynn Montross, *War Through the Ages* (New York: Harper & Brothers, 1960), 417 – 556; See Robert S. Quimby, *The Background of Napoleonic Warfare: The Theory of Military Tactics in Eighteenth-Century France* (New York: Columbia University Press), 1957.

[20] See Colin S. Gray, *War, Peace, and International Relations: An Introduction to Strategic History* (New York: Routledge, 2007), 31-48.

Charles Messenger notes, "Jomini, like von Clausewitz, set out to show that the nature of war had changed as a result of 1792-1815."[21] Clausewitz and Jomini were certain that the prescriptive methods of the previous century were obsolete. Both men subscribed to the uncertain antithesis of deterministic mechanics, seeking to prove "for once and for all that war is an art, not a science," though Jomini still went to great lengths to describe logistics, lines of operation, and other aspects of the scientific aspects of war.[22] This era, albeit not precisely the introduction of the term "operational art," marks the recognition of an ordered level of knowledge greater than tactics but subordinate to strategy, along with the recognition of the Art of War as belonging to the skillful application of the practitioner.[23] The two combined were the birth of operational art.

Napoleon's Wake

The scope and complexity of war had reached a threshold in the wake of Napoleon--awareness that the previous ordering of knowledge did not match reality. The early nineteenth-century paradigm of collective understanding consisted of the strategic state domain and the tactical military domain. Figure 1-1 can be used to represent the ordered environment of the collective state, with the center-point the perspective of a singular or collective observer. The fourth generation ordering of the cumulative knowledge is represented by the paths taken in Figure 1-2.

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[21] Jomini, *The Art of War,* vi.

[22] Ibid., vi.

[23] The term operational art emerged in the early twentieth century, born of Russian doctrine. For a lineage of operational art, see Michael R. Methaney, "The Roots of Modern American Operational Art" (US Army War College Paper, Carlisle, PA, n.d.), http://www.au.af.mil/au/awc/awcgate/army-usawc/modern_operations.pdf (accessed January 21, 2012).

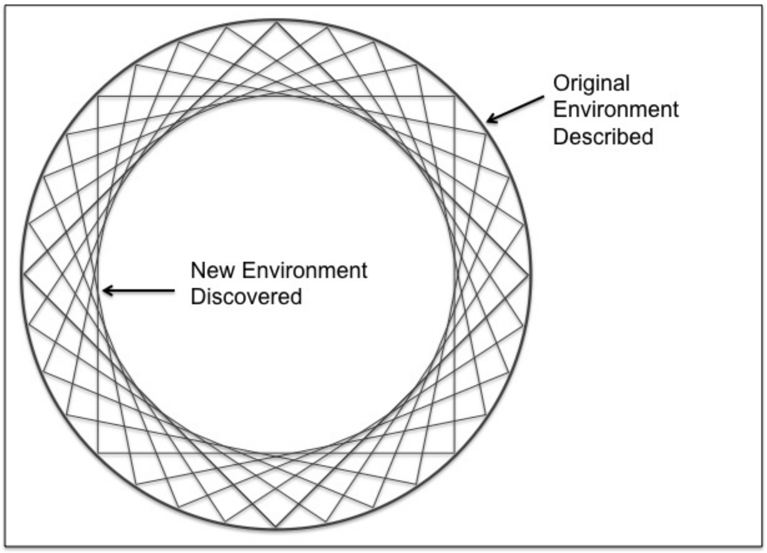

Figure 1-2: The Emergent Environment[24]

Each segment, while traveled in pursuit of precision, adds complexity to the equation of ordering one's environment. With the shaded area removed to reveal the intersection of the framing segments, it is clearly seen that within the broadest environment perceived (the strategic environment), there emerges an ordered environment at the intersection of the line segments. Even before reaching any sort of certainty of the original environment, a new environment within emerges, calling for greater exploration.[25] As cognition increases in complexity, either individually or collectively, levels of ordered knowledge develop.

Jomini was among the first to observe the emerging levels of order in war. Jomini's military art was non-prescriptive, except to follow his timeless principles,

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[24] See also Figure C-2: Points and Lines of Knowledge for an intermediate step between exploration and the emergent environment.

[25] There is a finite limit to the size of the smallest possible subordinate environment that can be inscribed inside of a circle. Limit, in this sense, means that the value of the sum of the area of the polygons is ever-decreasing towards a finite number, but never exactly equal to that number. The relationship between each successive set of polygons will form a mathematical pattern, or a function. The limit of this function can be roughly estimated with relatively few sets of polygons. Likewise, the limit of the area covered by the polygons within the circle approaches one of the most famous limits in calculus – the area of a circle estimated to be the diameter of the circle multiplied by the constant π. See Mathematical Association of America, *The Journal of Online Mathematics and Its Applications,* The MAA Mathematical Sciences Digital Library, Volume 7, 2007, http://www.maa.org/joma/Volume7/Aktumen/Polygon.html (accessed January 21, 2012).

allowing for the skillful application of knowledge in unique and seemingly unpredictable ways. His art, though, was still methodical and practical in execution. His methodical analysis of the history of warfare led to what he considered the most important chapter in *The Art of War*--his chapter on strategy.[26] Jomini contended that battles were fought over "the great questions of national policy and strategy," where strategy "directs armies to the decisive points of a zone of operations, and influences, in advance, the results of battles." Jomini continued with his analysis in describing "Grand Tactics" as "the art of making good combinations preliminary to battles, as well as during their progress."[27] Again noted by Messenger in his introduction:

> Here the term 'grand tactics' is especially significant. Much has been made in recent years of the Soviet term 'operational art', which represents the level of conduct of war that lies between strategy and tactics. Operational art, however, is merely another name for grand tactics, a level which Jomini identifies as 'the art of posting troops upon the battlefield according to the accidents of the ground, of bringing them into action, and the art of fighting on the ground, in contradistinction to planning upon a map.[28]

With Jomini's "grand tactics," the levels of war were beginning to emerge with clarity. An expanding realm of knowledge combined with a greater desire for certainty led the nineteenth-century theorists to frame this knowledge with the linear cognitive methods available to them, despite the aversion to geometric principles. Figure 1-3 shows a continuation of linear framing of the environment with Euclidean geometric analysis. The realm of tactics and strategy of the 1800s, as noted in Figure 1-2, was an expansion of a singular ordered environment in which a nested level emerged. Likewise,

[26] Jomini, The Art of War, xi.

[27] Ibid., 178.

[28] Ibid., vii-viii.

as the strategic environment pushed further outward, Jomini and his contemporaries recognized the emergence of a third level of warfare--grand tactics. And, as established in the previous excerpt from Messenger, this level today is equivalent to the operational level of war.

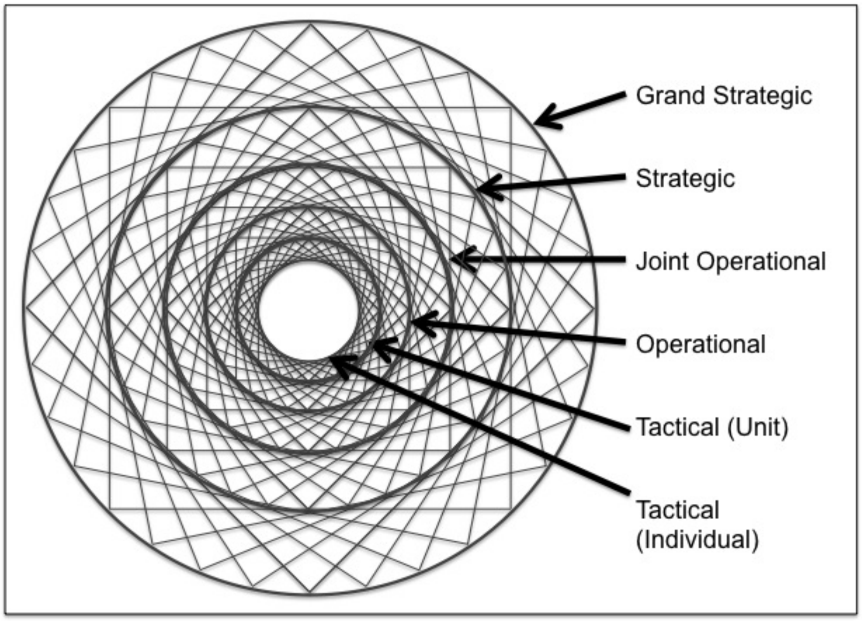

Figure 1-3: Levels of War

Figure 1-3 extends the linear framing to six levels, each with four internal orderings identical to the *a priori* man and his first exploration of an unknown environment. The expanse of knowledge in Figure 1-3 is representative of the state of today's strategic environment.[29] The level of complexity expands exponentially as the realm of knowledge one attempts to order pushes outward from an established perspective. Two points, connected by a single cognitive line segment, are seen as two observations connected by an analysis or evaluation of the relationship between those two points. The number of relationships in this two-dimensional, single instance (static) body

[29] John Paulos, *Beyond Numeracy: Ruminations of a Numbers Man* (New York: Alfred A. Knopf, 1991), 130. The process of inscribing polygons inside of a circle can be repeated an infinite number of times, with the innermost circle approaching closer and closer to 1/12 the size of the original environment.

of knowledge is nearly 200. Unfortunately, there are the same number of areas of uncertainty within this realm of knowledge, and more than 1,500 intersections of thought.[30] Further, with increasing clarity of the outermost environment, awareness develops of the existence of knowledge outside of the outermost bound of ordered knowledge, calling for an even greater level of ordering.

Clausewitz realized the absurdity of attempting to extend the Euclidean geometric tactics of the previous century into a study of the whole of warfare in the post-Napoleonic era.[31] The cognitive development of *a priori* man reached the number of observations in Figure 1-3 in just a few minutes from his first observation. Likewise, the complexity of warfare was well past any useful description with simple Euclidean geometry. But without a comprehensive understanding of nonlinear mathematics, which was just in its infancy at the time, Clausewitz was left to attribute the uncertainties and complexities of war to fog, friction, and chance.[32] Clausewitz's cognitive struggle against the deterministic theories of war of the eighteenth century is evident in Book 8 of *On War,* where he states:

> The insights gained and garnered by the mind in its wanderings among basic concepts are benefits that theory can provide. Theory cannot equip

[30] Recall from Figure 1 that the number of line segments and areas of uncertainty are both equal to 2^{n+1} within each environment (32 per level). With six levels, or environments, the total number of line segments is 192 in this model. The number of intersections follows the pattern of 4^n for a 4-sided polygon, hence the total number of intersections in the 6-level model is 1536. Keep in mind also that this is a simplistic model where connections between observations are drawn as segments rather than infinite lines, in which case each line would extend indefinitely, intersecting both superior and subordinate environments.

[31] Clausewitz, *On War,* 133-136. Clausewitz spends portions of Book Two denouncing previous theories of war inclusive of geometric siege tactics, simple numerical supremacy, and basic linear formations. Though unfinished, Book Two conveys the clear message that Clausewitz intended to present an antithesis to eighteenth century theories of geometric warfare.

[32] W. Gellert, S. Gottwald, M. Hellwich, H. Kastner, H. Kustner, eds., *The VNR Concise Encyclopedia of Mathematics, Second Edition,* (New York: Van Nostrand Reinhold, 1989), 406. The nonlinear mathematics referred to here is the analytical method of the infinitesimal calculus, developed near simultaneously by Wilhelm Leibniz and Isaac Newton in the second half of the seventeenth century.

> the mind with formulas for solving problems . . . but it can give the mind insight into the great mass of phenomena and of their relationships, then leave it free to rise in to the higher realms of action. There the mind can use its innate talents to capacity.[33]

As noted previously, faced with the realized uncertainty of the nature and conduct of war, Clausewitz and Jomini concluded war was both an art and a science, though certainly not a mechanistic science, and belonging more to the creative domain than the prescriptive domain.[34] Clausewitz spoke to the human element in war often, and even drew the analogy of the work of the general to that of an artist: "The immediate causes of our action may have different origins, just as the tone a painter gives to his canvas is determined by the color of the under-painting."[35] Clausewitz had no cognitive tool to explain the genius of Napoleon; the subtle hues of the painter were as mystifying as the genius of the commander. The metaphor of the artist was appropriate in 1827, but lacked depth of understanding. In 1976 when Clausewitz was introduced to large numbers of military officers and became part of an accepted theory of war, it ignored two centuries of intellectual development. Since then, "art" as an explanation for understanding has been bastardized to the extent that it has become a panacea for complex problems, inducing a fundamentally flawed foundation of military understanding.

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[33] Clausewitz, *On War*, 578.

[34] Both theorists heavily maintained the use of physical metaphor in their writings. Though likely not intended to be taken literally, the prominence of scientific terminology can leave the reader with an impression of a prescriptive theory. For use of physical metaphor in military doctrine see Joseph Brendler, "Physical Metaphor in Military Theory and Doctrine: Force, Friction, or Folly?" (School of Advanced Military Studies Monograph, US Army Command and General Staff College, Fort Leavenworth, KS, AY 1997-1998), http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA339484 (accessed January 21, 2012).

[35] Clausewitz, *On War*, 581.

Summary

The parallels between a post-war 1820 and the post-Vietnam era are plenty: an emergence from three decades of war, a geo-political transformation on a grand scale, and an influx of technological advancement. The set of fragmented military ideas, overwhelmingly inhibitive to coherent cognition, spawned the theory of Clausewitz in 1827 and baffled a humbled military establishment retreating from Southeast Asia in 1976. The Army in particular, "emerged far more disillusioned than it had after the Korean War."[36] The Army emerged seeking answers, and Clausewitz's fog and friction certainly seemed like the right metaphors to describe the Vietnam experience, particularly in the vacuum of military thought created by the destruction of the conventional way of thinking about war. Consistent dominance in tactical battles should have resulted in victory in the whole of war, but it didn't. The complexity of war was beyond simple, additive, linear relationships.

Chapter 2 will show that it was not just the metaphors of Clausewitz that were transposed onto the storyline of the twentieth century--it was an entire way of thinking. Clausewitz described some of Napoleon's campaigns as "genius" because he lacked the ability to explain Napoleon's thought process. So, just as Clausewitz and Jomini explained Napoleon's "genius" to the world, so did the tenets of *On War* become the intellectual guiding light for the military, particularly the Army, as it attempted to reset

[36] Andrew Krepinevich, Jr., *The Army and Vietnam* (Baltimore: Johns Hopkins University Press, 1986), 269. Krepinevich cites several reasons for the disillusionment: bitterness toward the political leadership, bitterness toward the American public, and inner-directed anger for fighting the war on the enemy's terms. Further, Krepinevich states that, "in Vietnam the Army ended up trying to fight the kind of conventional war that it was trained, organized, and prepared (and that it *wanted*) to fight instead of the counterinsurgency war it was sent to fight." Ibid., 271.

itself after Vietnam.[37] The theory of Clausewitz was artificially placed in an environment with no natural competitors and a humbled military establishment. The timing and conditions were right for the theory to dominate in the debates, the books, and the schoolhouses that would produce the military leaders of the twenty-first century. The nineteenth-century context, thus established, allows the story of Clausewitz leading military theorists out of the creative darkness to be resumed in 1976 with the publication of the Paret and Howard translation of *On War*.[38]

[37] Others reinforced the applicability of Clausewitz to twentieth century warfare, including Harry Summers, *On Strategy: A Critical Analysis of the Vietnam War* (Novato, CA: Presidio Press, 1995).

[38] See Methaney, "The Roots of Modern American Operational Art", for a thorough discussion of the evolution of operational art in the nineteenth and twentieth centuries.

CHAPTER 2: OUT OF THE WILDERNESS

Chapter 2 explores the influence of Clausewitz's nineteenth-century theory on the US military from the post-Vietnam Army doctrine to the Goldwater-Nichols era of joint doctrine in the 1990s. Metaphors such as fog and friction, as well as the underlying premise of chance and uncertainty, were applied to an increasingly complex military operating environment, further isolating the military thinker from true understanding of the nature of the environment. The collective military establishment chose to solidify its narrative doctrinal fallacy with the precepts of victory, while attributing the lessons of defeat to the anomalies of chance. The military, and particularly the Army, relied on the theory of Clausewitz to guide them out of the cognitive wilderness of the post-Vietnam era, only to arrive at a lurking disaster in the Iraqi desert. The geometric build of complex cognition continues in Chapter 2 with ordered levels of knowledge required to order an increasingly complex environment representative of the joint and combined military operations.

From a Hilltop in Vietnam to a School in Kansas

The foray into the era of modern doctrine begins with the post-Vietnam revision of US Army doctrine. Army Brigadier General Huba Wass de Czege is one of the well-known architects of this revision and the first director of the US Army School of Advanced Military Studies (SAMS). His perspective, much shaped by a long-held awareness of the chaos the insurgency in Vietnam imposed on military understanding, was influential in the introduction of operational art into the SAMS curriculum. Wass de Czege recognized the complex nature of war and the uncertain environment when he was "on a hill in Vietnam wondering why all the field grade officers above me hadn't a clue about what they were sending me out to do."[1] As with many officers, and indeed with Wass de Czege, these early perceptions as to the nature of war gain intensity and certainty the longer they are held, carrying with them the potential to forcefully impact others.[2]

Wass de Czege's perspective was widely shared, in particular by his successor a generation later, Colonel Kevin Benson, director of SAMS from 2003-2007. While researching the origins of operational art in modern doctrine, Benson concluded that the Vietnam experience directly influenced wholesale changes in the Army's doctrinal approach. "The miasma arising from the ashes of America's strategic defeat in Vietnam created an atmosphere conducive to the reconsideration of the role of the Army in strategy and operational art."[3] His research chronicles an atmosphere bearing much resemblance to that of today in terms of complexity and uncertainty. The Army was a humbled force searching for answers.

Benson observed, "The need for a unifying doctrine to face the conditions of the post-Vietnam era was reinforced by the complex conditions the Army and the nation faced at the time."[4] The world was changing faster than ever before, and the country, as well as the military, was struggling to order the new environment. The debates about the

[1] Kevin Benson, "Educating the Army's Jedi, The School of Advanced Military Studies and the Introduction of Operational Art into US Army Doctrine 1983-1994," (PhD diss., University of Kansas, 2010), http://kuscholarworks.ku.edu/dspace/bitstream/1808/7716/1/Benson_ku_0099D_11120_DATA_1.pdf, (accessed January 21, 2012), 21.

[2] High intensity, deeply held ideas hold certainty due to the number of cognitive observations as line segments framing the perception. These types of ideas will be seen to have high "mass" later in this work, and illustrate how the cognitive development of both an individual and a collective entity influence and define reality.

[3] Benson, "Educating the Army's Jedi," 53.

[4] Ibid., 3.

mission and composition of the force, the nature of current and future warfare, and the role of technology were brought to the public domain. Benson continues:

> A considerable number of articles published in *Military Review* and *Parameters* led to the rewriting of FM 100-5. The weight of articles also required a theoretical underpinning for any effort to rewrite the key operational doctrine of the Army. A new translation of Clausewitz' classic, *On War*, made the German philosopher's theory of war widely available to the US Army officer corps.[5]

The bitter, chaotic, maddening defeat in Vietnam brought about a doctrinal renaissance, but the promising new ideas selected as the underpinnings for a comprehensive theory of war were from an era where militaries were still trying to master operations based on the cannon and the musket.[6] The doctrinal renaissance ignored 150 years of advancement in human cognition and opted for its foundation the age of Newtonian mechanics and nineteenth century physical metaphor. Brilliant twentieth-century physicists like Planck, Einstein, and Heisenberg were ignored, as was two centuries of advancement in psychology.[7] This rediscovery of state-of-the-art 1827 theory has served as intellectual fodder in professional military education for nearly 30 years, prompting officers to debate vehemently in true Heller fashion, among other things, how Clausewitz's concept of center of gravity applies to counterterrorism or counterinsurgency.[8]

There was no new mathematical cognitive method introduced to provide a depth

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[5] Benson, "Educating the Army's Jedi," 43.

[6] Methaney, "The Roots of Modern American Operational Art," 19.

[7] Robert Coram, *Boyd: The Fighter Pilot Who Changed the Art of War* (New York: Back Bay Books, 2004). Air Force Colonel John Boyd used Planck and Heisenberg as the basis for his Observer, Orient, Decide, Act (OODA) decision cycle, which was influential on maneuver warfare, but a deep understanding of the OODA was bypassed in favor of an expedient acronym.

[8] Joseph Heller, *Catch-22* (New York: Scribner Paperback Fiction, 1994). Heller wrote Catch-22 as a satirical critique of military reasoning and circular logic; the 1827 reference alludes to Clausewitz's note written in 1827 as the final modification to *On War* prior to his death. See Clausewitz, *On War*, 67.

of understanding or a unique order to the environment, and therefore the military theorist was still trying to fit a world with a seemingly infinite number of variables into a Euclidean framework. In Chapter 1, Figure 1-3 continued the development of complex cognition with the introduction of the emerging levels of war apparent to Clausewitz and Jomini, ordered with Euclidean-type precision. Figure 2-1 shows Clausewitzian-era cognition applied to a state of warfare that had continuously evolved for 150 years to an early state of joint warfare representative of the post-Vietnam era. This joint environment in Figure 2-1 encompasses multiple perspectives of Service tactics, exponentially increasing the complexity of the problem. If just one out of every ten tactical concepts intersects another tactical concept (there are thirty-two line segments, or concepts, within each tactical Service environment) with significant implication, by Euclidean framing there are 500 million possible combinations of how these Service concepts will intersect.[9] Clearly Euclidean geometry wasn't the solution to order 500 million possible combinations of tactics, but neither was the "blind natural force of the play of chance and probability within which the creative spirit is to roam."[10] The growing complexity of war was already on an unsteady cognitive framework nearly forty years ago; reality has eroded the foundation even further in the decades since.

[9] Gellert, *The VNR Concise Encyclopedia of Mathematics, Second Edition,* 576. If n represents the distinct elements in a set, then the number of permutations, or possible combinations, of those elements is represented mathematically by n! (n factorial). The value of n! is calculated by multiplying (1) (2) (3)…(n-2)(n-1)(n). The total Service concepts represented by this model is 128, so (128/10)!= 479,001,600. The model in Figure 2-1 is a realistic depiction of the joint environment of the post-Vietnam era; 32 concepts for a Service to employ its force in a joint environment is, in fact, an overly simplistic estimation, as is the estimation that only 10% of individual Service tactics do not fit neatly into a joint environment without impacting another Service's efforts.

[10] Clausewitz, *On War,* 89.

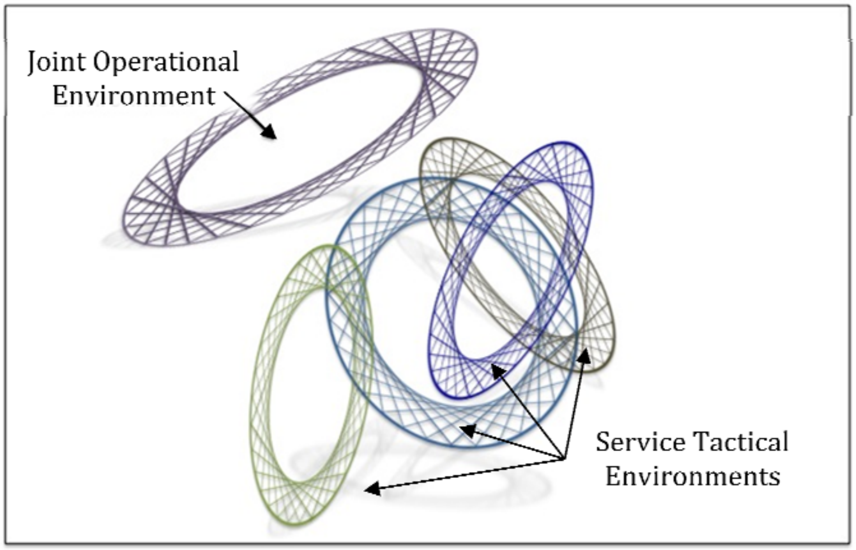

Figure 2-1: The Complexity of the Joint Environment[11]

The 1982 version of Field Manual (FM) 100-5, Operations, introduced the operational level of warfare into doctrine, but the definition of operational art wasn't formally codified in military doctrine until 1986. In 1986, the Army described operational art in the 1986 version of FM 100-5 as, "the employment of military forces to attain strategic goals in a theater of war or theater of operations through design, organization, and conduct of campaigns and major operations."[12] Operational art was simply the practice of warfare at the level between strategy and tactics. Although 1986 marks the doctrinal inception of the operational level of war, the concept of grand tactics was prevalent in US military theory for most of the twentieth century.[13]

That year, 1986, also marked another seminal event--the passing of the Goldwater-Nichols Department of Defense Reorganization Act, in which "operational

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[11] See also Figure C-3: Three Dimensional Arrangement, for a nonsymmetrical complement to Figure 2-1.

[12] Department of the Army, *Operations: Field Manual 100-5* (Washington, DC: US Department of Defense, 1982), 10.

[13] Methaney, "The Roots of Modern American Operational Art," 19-21.

authority was centralized through the Chairman of the Joint Chiefs as opposed to the Service chiefs." Furthermore, the act stated that to be effective, the joint force must be truly integrated, "intellectually, operationally, organizationally, doctrinally, and technically."[14] The first Joint Operations doctrine followed in 1993, with the Army as the lead agency for the effort. The concept of operational art was expanded, but was not fundamentally changed. Operational art became:

> The employment of military forces to attain strategic and/or operational objectives through the design, organization, integration, and conduct of strategies, campaigns, major operations, and battles. Operational art translates the joint force commander's strategy into operational design, and, ultimately, tactical action, by integrating the key activities of all levels of war.[15]

The first joint definition of operational art recognized the increasing complexity and uncertainty of the early 1990s with unclear implications for the force, but operational art was not yet "a way of thinking" in doctrine--it was not needed. The Cold War had officially ended, and the US concluded a swift Operation DESERT STORM with superior technology and massive joint firepower. Joint operations were clearly effective from the perspective of the Joint Chiefs and the Services; from this perspective there was no need to reexamine the cognitive process or the theoretical underpinnings of doctrine. Through the lens of victory, joint operational art was simply the continued inclusion of the most universal, and most successful, Service concepts into joint form. Joint doctrine was widely celebrated as a success.[16]

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[14] National Defense University, "Goldwater Nichols Department of Defense Reorganization Act of 1986," http://www.ndu.edu/library/goldnich/goldnich.html, (accessed January 21, 2012).

[15] Joint Chiefs of Staff, *Joint Operations: Joint Publication 3-0* (Washington DC: US Department of Defense, 1993), GL-12.

[16] For Navy perspective, see Department of the Navy, *The US Navy in Desert Shield/Desert Storm* (Washington, DC: Department of Defense), http://www.history.navy.mil/wars/dstorm/ds3.htm (accessed January 21, 2012).

Another Forgettable Engagement

The triumph was short-lived, for later in 1993, the US suffered through the now infamous Battle of Mogadishu, in which the chaos of a failed state collapsed upon Task Force Ranger, bringing scenes of destruction to television sets around the globe. Despite favorable casualty ratios reminiscent of Vietnam, the US withdrew in defeat, turning the reflection of the military inward once again. In post-operations review, the US Army War College Institute for Strategic Studies described Somalia as an "unpredictable environment" and concluded that the uncertainty in Somalia underscored the importance of understanding "the strengths and limitations of the United Nations and other international institutions."[17]

The uncertainty of the environment and the complexity of multinational operations were greater than ever before--and changing with unprecedented acceleration. Yet still there was no theoretical foundation underpinning doctrine with a level of understanding proportionate to the complexity and uncertainty of the times. The continuing disparity left the military establishment seeking explanations and clinging to faith in the "inshallah" approach--an approach that shirks from the friction of complexity and lacks the critical thinking required to pierce the fog. General Norman Schwarzkopf, commander of US Central Command (USCENTCOM) during Operation DESERT STORM, held the perception that USCENTCOM's success was due in part to "good old American ingenuity" and the creative thinking of planners.[18] The divine ability of

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For Air Force perspective, see Don P. Chipman, *Desert Storm and the Triumph of Joint Warfare Planning* (AirPower History Online: Spring, 2005), http://findarticles.com/p/articles/mi_hb3101/is_1_52/ai_n29166188/

[17] Kenneth Allard, *Somalia: Lessons Learned* (Washington, DC: CCRD Publication Series), http://www.dodccrp.org/files/Allard_Somalia.pdf (accessed January 21, 2012), 80.

[18] Norman Schwarzkopf, *It Doesn't Take a Hero* (New York: Bantam, 1993), 582.

USCENTCOM mission planning was also highlighted as one of the few bright spots of Operation RESTORE HOPE in Somalia, citing planners skilled in “orchestrating literally thousands of details . . . , adjusting those details when the concept of the operation changes . . . , and doing all of these things under time pressures that would cause breakdowns in lesser mortals . . . , adapting formerly standard procedures to new and uncertain tasks.”[19] In the cognitive shadows of defeat, remaining perceptions of previous victories were attributed to creativity.

In a 1993 essay reviewing the tenets of doctrine used in Somalia and Iraq, Dr. Stephen Metz, professor of Strategic Studies at the US Army War College, observed, “The basic philosophy of war used by the US military remains Clausewitzian.”[20] Colin Gray agreed in his review of strategic history, as he asserted, “The theory we have available to us is largely the product of Prussian soldier Carl von Clausewitz.”[21] So then, it follows that the modern doctrinal foundation, and hence the conceptual approach that underwrites military operations, is from 1827. Worse still, the theory of Clausewitz largely avoids exploring the complexity of the human dimension. Clausewitz believed that “no theorist, and no commander, should bother himself with psychological and philosophical sophistries.”[22] Certainly neither Metz nor Gray implied that the original theories of Clausewitz had not been modified, but that the framework remained Clausewitzian. How, then, does an eighteenth-century framework that decries the

[19] Allard, *Somalia: Lessons Learned*, 20.

[20] Steven Metz, “A Wake for Clausewitz: Toward a Philosophy of 21st-Century Warfare,” *Parameters* (Winter 1994-1995): 126-132. Metz was not reviewing the doctrine for specific application in Somalia or Iraq; however, at the time of his essay (1993) the doctrine in question was the same used for both operations.

[21] Gray, *War, Peace, and International Relations*, 15.

[22] Clausewitz, *On War,* 137.

relevance of psychological inquiry support a theory of war applicable to modern social structures like Somalia? The contradictions are inexpiable.

Clausewitz, as noted, introduced many valuable observations to the study of warfare that had never before been enunciated with the same astuteness, but he did not introduce an analytical method to deal with the increasing complexity of the environment. In fact, concepts like chance and uncertainty introduce an easy stopping point when understanding is taxed. Likewise, the truisms of fog and friction assert that "things go wrong in war," and open a cognitive escape route from the fragments that contradict more thoughtful conclusions.[23] Yes, Clausewitz's observations of fog and friction still apply to war in the twenty-first century, but only in a sophomoric, introductory level of analysis. They leave the military theorist no closer to explaining and understanding the *coup d'oeil* commanders seek in war.

With no new cognitive method to understand the military environment, the theorist of 1993 was again left with the same linear cognitive approach used in 1976 or in 1827. But the realization that the world did not unfold in linear patterns left much uncertainty within the cognitive framing, with many observations attributed to the "fog and friction" phenomena. Figure 2-2 illustrates a Clausewitz-era approach to the operational environment of 1993 to demonstrate the futility of the old way of thinking. The tactical domains are those developed in Figure 2-1, but in a joint and combined environment, each coalition partner brings tactical concepts that may or may not align with US tactics. Combined operations add a degree of complexity to the both the operational and tactical levels, resulting in a set of tactical combinations that is, for all

[23] Clausewitz, *On War*, 25.

intents and purposes, infinite. The environment of war continued to increase in complexity, but the cognitive method did not evolve to match.[24]

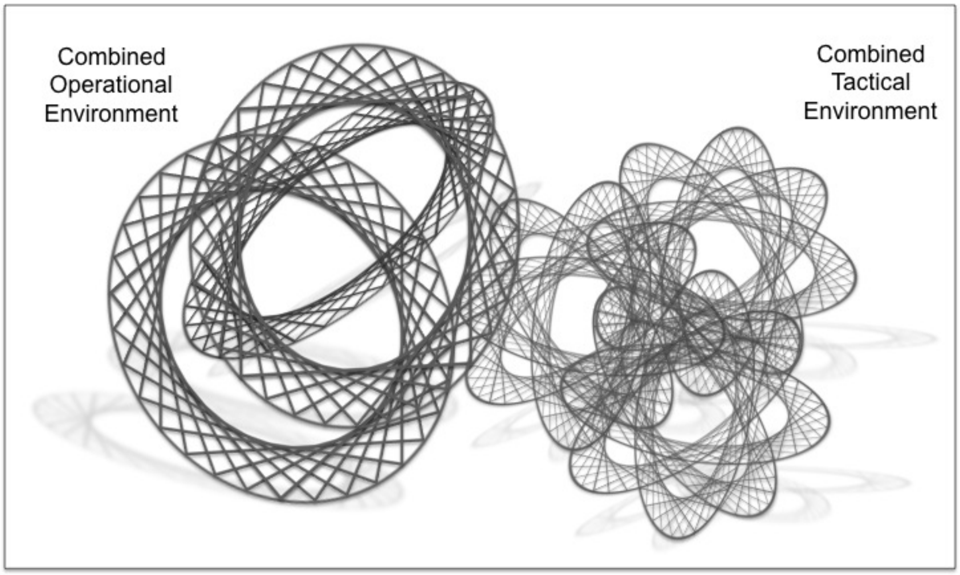

Figure 2-2: Building Complexity of Combined Operations[25]

A Deepening Crisis

The psychology of social perception contains a set of perception fallacies, including "dramatic instance fallacy," in which the viewer uses one or a few cases "to support an entire argument."[26] The result is a faulty perception model of the situation based on flawed causal analysis. In his book *Deep Survival,* Laurence Gonzalez

[24] The tactical and operational environments are shown as distinct in Figure 2-2 to illustrate the cognitive intersections contained within each level of war. The tactical environment here is representative of just three perspectives, each of those perspectives with a set of cognition that must be fully considered and integrated into the whole of the collective cognition at the operational level. Still, there are a total of 384 tactical concepts, depicted as line segments, cognitively framing the nonlinear tactical environment. Likewise, there are multiple operational perspectives that must be combined and integrated at a higher level for a total of 96 operational concepts depicted in the cognitive model of Figure 2-1, each adding to the complexity of intersecting ideas and unknown or uncertain areas. The illustration is intended to convey the realization that without a new cognitive method introduced to understand the complexity of war, the additional concepts added as complexity increases only further deepen the confusion.

[25] See also Figure C-4: Expanding Knowledge, for a nonsymmetrical complement to Figure 2-2.

[26] Robert Lauer and Jeanette Lauer, *Social Problems and the Quality of Life* (New York: McGraw-Hill, 2004), 41-49.

evaluates the application of flawed perception models in survival situations. Many accidents, or flawed executions, occur because "you see what makes sense, and what makes sense is what matches the mental model."[27] Nassim Nicholas Taleb dedicates an entire chapter in *The Black Swan* to such "narrative fallacies."[28] The collective military apparatus saw, and still sees, what it wanted to believe in the wake of Operations DESERT STORM and RESTORE HOPE.[29] Somalia was characterized as the anomaly, while Operation DESERT STORM matched the mental model of the precise execution of a sound doctrine.[30] Operation DESERT STORM was the validation of the collective Army perception that there was nothing positive to be learned from Vietnam--a comforting return to "conventional" operations.[31]

Contrary to more palatable conclusions, DESERT STORM was essentially a battle--a limited engagement with no advanced-phase stability and security requirements. It was a battle in which the most powerful military in the history of warfare faced down an outmoded, undisciplined military from the 58th largest nation in the world. But instead of viewing DESERT STORM as a successful lop-sided battle, it was seen as a validation of military theory, and by extension military doctrine. Bruce Menning, describing the

[27] Gonzalez, *Deep Survival,* 162.

[28] Nasim Taleb, *The Black Swan* (New York: Random House, 2007), 62-83.

[29] During a lecture to the Joint Advanced Warfighting School on 19 January 2012, Retired General Carl Stiner, who served as the Joint Task Force commander for Operation Just Cause in Panama, was asked if there was a parallel between the concept of operations chosen in Panama by the XVIII Airborne Corps and the catastrophe that befell the same elements in Somalia. General Stiner did not see a parallel and attributed the outcome of the Battle of Mogadishu to tactical errors and mission creep.

[30] Mark Bowden, *Blackhawk Down* (New York: Penguin Books, 2000), 331-332. Bowden, in the epilogue to *Blackhawk Down,* describes the near complete void of information evaluating the Battle of Mogadishu, and concludes that both the military and political establishment wished to close the door on the episode as quickly as possible without serious critical analysis.

[31] See Krepinevich, *The Army in Vietnam.* Krepinevich throughout his work questions the Army's collective ability to learn the painful lessons of Vietnam and apply them to doctrine in a meaningful way.

operational art on display in Operation DESERT STORM, declared, "The conceptual tools inherent in the US understanding of operational art, including center of gravity, played an important part in the calculus that brought allied victory."[32] When a tractor-trailer traveling 70 miles per hour strikes a bicycle, it doesn't really matter where the center of gravity lies. The conclusion is archaic in understanding. "To deal with reality, you must first recognize it as such."[33]

The perception of success solidified and grew, however, with the addition of advanced technology and rapid maneuver concepts onto the framework of AirLand battle. Less kinetic at the outset, and therefore less decisive, the Army categorized operations like Operation RESTORE HOPE in Somalia as Military Operations Other Than War, while developing a doctrine of overwhelming force for conventional operations in which the US would "obtain perfect or near perfect information on virtually all technical aspects of the battlefield."[34] Confidence in the supremacy of US military technology and doctrinal concepts was the beacon guiding the joint force through the 1990s, migrating from Service doctrine into joint doctrine with the "doctrinal reincarnation of operational art in joint guise."[35]

Summary

The joint doctrinal concept of operational art introduced in 1993 was not novel. The 1993 version of Joint Publication 3-0, *Joint Operations,* went into further detail

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[32] Bruce Menning, "Operational Art's Origins," *Military Review* 77, no. 5 (September–October 1997): 32–47.

[33] Gonzalez, *Deep Survival,* 51.

[34] Harlan K. Ullman and James P. Wade, *Shock and Awe: Achieving Rapid Dominance* (Washington, DC: Center for Advanced Concepts and Technology, 1996), 11.

[35] Menning, Operational Art's Origins, 46.

describing the level that emerged between the tactical concepts and strategic tenets of warfare, but it did not emphasize the creativity of the planner or the genius of the commander. In essence, it stayed true to the traditional view of art as the "skillful application" of concepts and theory. Subsequent editions of JP 3-0 in 1995 and 2001 did not alter this view. It was not until 2006 that operational art took its creative left turn.

Metz concluded that, if indeed Clausewitz were obsolete, then "there could be extraordinarily dangerous times ahead as we prepare for unlikely types of conflict."[36] Doctrinally, what lay ahead was the emergence of Effects Based Operations, but not before the perceived success of Airland Battle doctrine in DESERT STORM led to the technologically infused fallacy of "Shock and Awe." While operational art was relatively static from 1993 until 2006, the world did not stand still. The air power on display in Bosnia/Kosovo and the early days of Operation ENDURING FREEDOM in Afghanistan did nothing to dissuade the growing awe inspired by the US military. A US-led North Atlantic Treaty Organization mission forced the surrender of Milosevic without a ground invasion and not a single airman lost.[37] Millions watched the Northern Alliance waltz into Kabul under the protective umbrella of US Special Forces and precision air power, all guided by the intelligence of the Central Intelligence Agency.[38] The Iraqi disaster was lurking in plain sight, waiting to strain to its limit the cognitive framework of military understanding.

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[36] Metz, "A Wake for Clausewitz," 131.

[37] See Wesley Clark, *Waging Modern War* (Cambridge: Persius Books Group, 2001).

[38] See Gary Schroen, *First In: An Insider's Account of How the CIA Spearheaded the War on Terror in Afghanistan* (New York: Random House, 2005).

CHAPTER 3: A MANUAL FOR THE JOINT LAITY

The state of joint doctrine and the military theory supporting it left the establishment very much unprepared for protracted conflict when Operation IRAQI FREEDOM took its turn toward a persistent insurgency in 2004. The theoretical framework could not support the degree of complexity created by new technologies, new media, and an expanding awareness. Further, the uncertainty of both the Iraq and Afghanistan insurgencies caused an abrupt retreat from any sort of prescriptive methods in doctrine, leaving in its place a vacuum of thought. The military establishment ushered in the "creative imagination" of the commander to fill the void. The unexpected, and much accidental, turn away from art as the "skillful application of the practitioner" completes the investigation into the crisis in cognition at the point where the fragments from a contradictory theory are creatively pieced together with operational art. The build of complex cognition continues in Chapter 3 toward an understanding of a changing environment, and sets the stage for the introduction of a new way of thinking.

Fragments of Perception

Volumes have been written, with many more to follow, about what went wrong in Iraq. Conclusions as to the cause of the protracted insurgency vary, from lack of interagency coordination and the polarizing effect of Secretary of Defense Rumsfeld, to the field force being too small and unprepared for counterinsurgency warfare, and flawed assumptions inherent in "Shock and Awe."[1] No reasonable man would view the US efforts in Iraq from 2004-2006 as successful. Regardless of one's conclusion as to the

[1] See Ullman and Wade, "Shock and Awe," for a description of the tenets of a "Shock and Awe" approach to warfare.

cause or causes of the failure, worlds collided, as a reincarnated eigth-century fundamentalist Islam was able to assert its influence in modern-day Mesopotamia by combining emerging technologies with relatively simple tactics and techniques and manipulating public perception through new media.[2] By 2006, one thing was certain--the cold calculations of Effects Based Operations (EBO) and Net-Centric Warfare simply were not working as advertised in the human dimension.

EBO emerged in the late 1990s as a methodology to predict and measure the effects of weapons systems and operations on a target. Its origins can be found in the effective speed, precision, and power displayed in Iraq in 1991 and developed and nurtured, primarily by the Air Force, into what became a prescriptive, deterministic planning equation. Those educated in the school of Clausewitz, particularly the Army and Marine Corps, vehemently opposed the presumptive arrogance assumed in this predictive doctrine, particularly in light of the casualties those Services suffered in Iraq and Afghanistan. A chorus of opponents, led by Marine Corps General James Mattis, battered EBO with truisms like: "War cannot be precisely orchestrated"; "[War] by its nature is unpredictable"; and "You cannot change the fundamental nature of war."[3]

Certainly the human dimension of warfare seemed to betray clear understanding. One of the key issues of the debate about EBO was the attitude "about uncertainty and

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[2] The conclusion is based upon the author's own experience in Iraq in 2007 at the height of the insurgency. For an historical account of the resurgence of fundamentalist Islam, see Albert Bergesen ed.,*The Sayyid Qutb Reader: Selected Writings on Politics, Religion, and Society* (New York: Routledge, 2008).

[3] Greg Grant, "Ground Forces Best: Mattis," *DoD Buzz: Online Defense and Acquisition Journal* (June 2009), http://www.dodbuzz.com/2009/06/02/ground-forces-best-mattis/#ixzz0t80sDysB (accessed January 21, 2012).

the feasibility of achieving control over complex, adaptive, human systems."[4] Mattis, as commander of the Marine Corps Combat Development Command, said,

> You cannot take down a government . . . the same way you can an electrical grid . . . . When you enter into the areas where human beings--with their will power, their imagination, their courage, their fears, their cultural tendencies--all come to bear, the idea that you can put an algebraic equals sign between something you do and the response that you're going to get is not borne out by the last 5,000 years of human interactions on this planet.[5]

General Mattis, as did Clausewitz before him, rejected Euclidean geometry (or the algebraic equivalent) and prescriptive, mechanistic doctrine. Mattis and Clausewitz based their conclusions on personal observation of war and astute study of history. They realized firsthand the complexity and uncertainty inherent in conflict. Both were repudiating a simplistic, mechanistic, reductionist approach, and correctly so; however, relying on fog, friction, and creativity as a theory presents a dangerous alternative.

Many officers who experienced the seemingly chaotic and unpredictable operational environments in Iraq and Afghanistan shared these observations. A tactically, technically, and intellectually unsophisticated enemy destroyed the cognitive model of warfare held by US officers. The military establishment was seeking answers, but not in science books. Brian Greene explains the aversion to scientific explanation: "Many find it fatuous and downright repugnant to claim that the wonders of life and the universe are mere reflections of microscopic particles engaged in a pointless dance fully choreographed by the laws of physics."[6] Mattis, and those who witnessed so much death and destruction in Iraq and Afghanistan, also found the concept of a deterministic

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[4] Paul Davis and James Kahan, *Theory and Methods for Supporting High Level Military Decision Making* (Arlington, VA: Rand Corporation, 2007), 59.

[5] Ibid., 59.

[6] Brian Greene, *The Elegant Universe* (New York: Random House, 1999), 16.

humanity repugnant. The experience caused a sharp withdrawal from precise and predictive methods, much like those in EBO, in favor of operational canons that promoted the unpredictability of war.[7]

Mattis officially ended EBO in 2008 based on his "own personal experiences and the experience of others in a variety of operational situations," but the demise of EBO was understood by Joint Forces Command (USJFCOM) well before 2008.[8] USJFCOM was assigned the task in 2004 of revising Joint Publication 3-0. The rewrite was prompted by the decision to combine Military Operations Other Than War (MOOTW) with conventional warfare and to begin moving away from the more deterministic tenets of EBO, although the initial guidance was to include some elements of EBO. The process of significant doctrinal revision is not simple--concepts are integrated across domains, Services, and functions. The removal of a deep-rooted complement to traditional kinetic action, such as MOOTW, without a theoretical premise to order the pieces was sure to create more uncertainty.[9]

The famous fighter pilot John Boyd, in the monograph that became the foundation of the Observe, Orient, Decide, Act (OODA) Loop, discussed such a disruptive impact on cognitive order:

> Suppose we shatter the correspondence of each domain or concept with its constituent elements. In other words, we imagine the existence of the parts but pretend that the domains or concepts they were previously

[7] Joint Chiefs, *JP 3-0: Joint Operations,* iv. One example from the 2006 revision of JP 3-0 is the movement of 17 operational elements to operational design from the previous concept of operational art. Things considered more prescriptive didn't belong in a creative way of thinking.

[8] US Joint Forces Command, *Memorandum: Assessment of Effects Based Operations* (Washington, DC: Department of Defense, 2008), http://smallwarsjournal.com/blog/assessment-of-effects-based-operations-updated (accessed January 21, 2012).

[9] The analysis of more uncertainty created is that of the author of this thesis, not the authors of JP 3-0.

> associated with do not exist. Result: We have many constituents, or particulars, swimming in a sea of anarchy. We have uncertainty and disorder in place of meaning and order.[10]

A visualization of a fragmented collective cognitive order is difficult, and impractical using Euclidean methods. The strategic environment of the twenty-first century includes perspectives of multiple strategic partners, combined and integrated joint functions, and Service tactics from a host of nations merged on the battlefield. Figure 3-1 continues the build of a complex cognitive model, framed with the linear segments (relationships) built thus far in this thesis. The figure depicts a single tactical environment, though still with multiple Service perspectives, nested within a combined joint environment. The joint environment is subordinate to a multinational strategic environment. Again, for simplicity, the concepts of each respective environment are finite line segments connecting two cognitive points within a single level of knowledge.

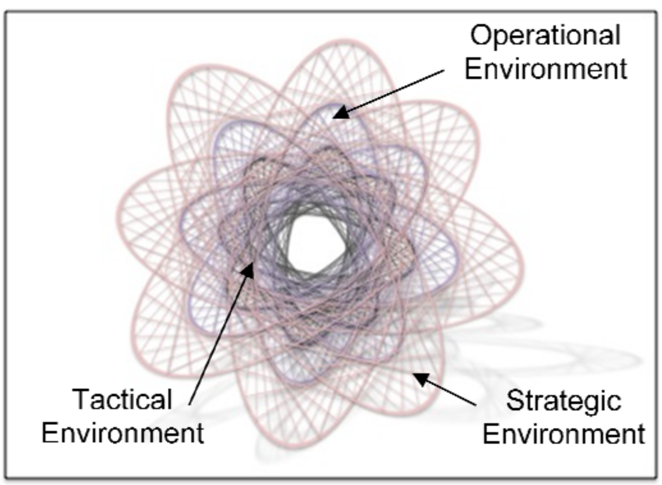

Figure 3-1: Complex Levels of War[11]

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[10] John Boyd, "Destruction and Creation," http://pogoarchives.org/m/dni/john_boyd_compendium/destruction_and_creation.pdf (accessed January 21, 2012), 3.

[11] Figure 3-1 Illustrates a tightly arranged system of knowledge, symmetrically linking concepts within levels, and nesting levels within a heirarchical arrangement of information. At the core of knowledge, individual or collective, one's most intense beliefs and certain facts are arranged in this

Each level of war in Figure 3-1 contains relatively few concepts--just 128 unique relational values, contrasted for example to the voluminous 877-page Universal Joint Task List published in 2005 to describe a standard of training for joint tasks.[12] The authors of joint doctrine were faced with more uncertainty and complexity than ever before, but still without a theory of war capable of accommodating the weight of such an undertaking. No new translation of a nineteenth-century scholar or a novel understanding of the classics would emerge from the metaphorical fog or friction to provide clarity to such a complex environment. Instead, creative operational art would have its day.

The Twenty-First-Century Operational Artist

Uncertainty and disorder were prevalent themes in 2006 as then-Army Lieutenant Colonel James Purvis was designated the lead officer for a doctrinal development group charged with the task of rewriting JP 3-0. Faced with the uncertain context of Iraq and Afghanistan, and given the explicit guidance by senior leadership to exclude EBO, Purvis and the group focused on operational art. The definitions and terminology of traditional military operations, as well as those of MOOTW, combined into a single doctrine defied any underpinning logic. There had to be something more--a creative aspect to

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manner. As information is understood with less certainty, the arrangement is much less symmetrical and orderly.

[12] Joint Chiefs of Staff, *CJCSM 3500.04D: Universal Joint Task List, Change 1* (Washington, DC: Department of Defense, 2005). The UJTL is used to demonstrate that there are thousands of tactical "tasks" or concepts which must be fully integrated into a singular cognitive picture. These concepts, in reality, overlap and intersect an infinite number of times. To bin them into neat geometrical cognitive areas is not possible. The complex levels of war in Figure 3-1 represent an expanding awareness – from the route of *a priori* man, it was shown that the more certain one becomes of a given environment, both subordinate and superior environments gain clarity. The same is true as military knowledge expands. The more certain commanders became of tactics, they became aware of the need for an operational level of war. By the second half of the twentieth century, the tactical, operational, and strategic levels were all defined with an abundance of line segments--precepts belonging to that level of war. Assuming only 5% of these concepts used to order observations in the environment impact another relational value within the same level of war (i.e. they intersect another segment), at any single instant in time there are 6.4×10^{15} possible arrangements of the environment.

complement the mechanistic definitions. "You could teach anyone to put the pieces and parts together, but it takes a certain amount of creativity to pull off some of the more genius aspects of war."[13]

A new definition of operational art emerged from the pieces in 2006 as:

> The application of creative imagination by commanders and staffs--supported by their skill, knowledge, and experience--to design strategies, campaigns, and major operations and organize and employ military forces . . . . It is the thought process commanders use to visualize how best to efficiently and effectively employ military capabilities to accomplish their mission. While operational art is the manifestation of informed vision and creativity, operational design is the practical extension of the creative process.[14]

The authors consulted Sun Tzu and Jomini, Clausewitz and Mao, and were given broad guidance from the Chairman and the USJFCOM commander. However, the shift in perception from art as the practical and skillful application of theory--the artistry of the practitioner--to creative imagination of the commander, originated with a single author, retired Marine Lieutenant Colonel Robert Hubner.[15]

Hubner, as did Purvis, recognized the fragmented state of the "keystone document" that was intended to provide "the doctrinal foundation and fundamental principles to guide the armed forces."[16] The new JP 3-0 introduced the concept of Joint Functions, redefined the range of military operations, extended the phasing model for military operations, and combined traditional principles of war with the principles of

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[13] James Purvis, interview by author, Norfolk, VA, December 20, 2011.

[14] Joint Chiefs of Staff, *Joint Operations: Joint Publication 3-0* (Washington DC: US Department of Defense, 2006), IV-2 - IV-3.

[15] Robert Hubner, interview by author, Suffolk, VA, January 18, 2012. Hubner also noted that the debate over EBO became so contentious that there was near mutiny in the working group.

[16] Joint Chiefs, *Joint Operations*, 3.

MOOTW.[17] Hubner characterized the draft doctrine as "lots of loose ends" and the underlying theme for JP 3-0 was that "the commander had to be prepared to do lots of stuff--to design, plan and execute a wide range of military operations all over the globe."[18]

A second theme that eventually emerged in the 2006 version of JP 3-0 was the distinction between operational art and operational design. Design, with strong Army advocacy, became the more "scientific" or practical aspect of operational planning--a framework or process for the details to support the commander's concept.[19] Operational art, in the context of a fragmented doctrine with a mechanistic design element, needed redefining. Hubner concluded that if design were a process, then for an artist design would imply "paint by numbers." Art, then, was in the person. It was intuitive. A master--a Renoir, a Van Gogh, a Monet--could and should paint shades and hues without prescriptive step-by-step instructions. Hubner, seeking alternatives, consulted the dictionary for the definition of art and found something akin to "a skill acquired by observation, experience, or study."[20] Still unsatisfied, Hubner resorted to his own sense of art and drafted the description of operational art as "the application of creative imagination by commanders and staffs."[21]

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[17] The 2006 version of JP 3-0 also replaced the model of intelligence preparation of the battlefield with the joint intelligence preparation of the operational environment.

[18] Robert Hubner, interview by author, Suffolk, VA, January 18, 2012.

[19] The perspective of Design discussed herein is that of Hubner recalling the development of the 2006 JP 3-0, primarily represented by the SAMS curriculum; see Joint Staff, *Joint Publication 3-0: Joint Operations,*(Washington, DC: US Department of Defense, 2011), II-4: "Operational Design extends operational art's vision with a creative process that helps commanders and planners answer the ends-ways-means-risk questions."

[20] Websters Online Dictionary, http://www.merriam-webster.com/dictionary/art?show=1&t=1327019424 (accessed January 21, 2012).

[21] Hubner Interview; Of interest, the 2011 version of Joint Publication 3-0 altered the definition of Operational Art to "the cognitive process by commanders and staffs" in the glossary, but the "creative

Much by accident, creative imagination stuck. The working group staffed the draft publication. Astoundingly, none of the nearly 4,000 comments expressed concern with the new definition of operational art. The final draft went to the Joint Staff and gained approval without comment.[22] The ambiguity, uncertainty, and complexity of a world would now be understood, navigated, and conquered with creativity and imagination.

Joint doctrine does not go into depth about what exactly constitutes creativity, but Webster's Online Dictionary defines creativity as "having the quality of something creative, rather than imitated."[23] Similarly, Mark Pagel discussed the unique creativity of humans in contrast to the acts of imitation performed by less intelligent species: "Only humans seem to be able to select, among a range of alternatives, the best one, and then build on that alternative . . . and to improve upon it. And so, our cultures cumulatively adapt, whereas all other animals seem to do the same thing over and over."[24] The military "culture" was looking for something new to order its collective cognitive

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imagination" text remains in the body of the document. The definition coined by Hubner above remains mostly unchanged in the 2011 version of Joint Publication 5-0. The continued contradiction in undersanding of nonlinear cognition appears to have manifested itself in the design concept discussed in both of these publications. This work only studies the crisis through the 2006 doctrinal evolution, though the author recommends the reader continue the analysis set forth in these pages to the 2011 doctrinal iteration. See Joint Staff, *Joint Operations*, Chapter II as well as Joint Staff, *Joint Operation Planning,* Chapter III.

[22] Hubner Interview. Hubner could not recall any comments of significance concerning the new definition of art. The definition in the final draft submitted to the Joint Staff was identical to the one he drafted in his office in Suffolk. Hubner noted that by this point in the doctrine development, he had earned the trust of the working group, and none raised any objection to his proposed definition.

[23] Webster's Online Dictionary, http://www.merriam-webster.com/dictionary/creative (accessed January 21, 2012).

[24] Mark Pagel, "Infinite Stupidity: A Conversation with Mark Pagel," *Edge*, http://edge.org/conversation/infinite-stupidity-edge-conversation-with-mark-pagel (accessed March 30, 2012); Chapter 5 of this thesis describes the act of creation as a mathematical synthesis, or integration, of previously disparate parts to form a new whole. The perspective of creation above--that of seeking something new out of a desperate attempt to survive--should be kept in mind as contrasted to the perspective of creation as a previously undiscovered, ordered solution that fits within the parameters of a given function to solve a problem.

environment, something to allow it to adapt and survive, just as any set of thinking, reasoning individuals has done throughout history. Rote applications of a mechanistic approach--checklists for thinking--were precisely the opposite extreme of the new order desired, and so the establishment chose creativity.

Creativity is, without doubt, a quality to be sought by planners and commanders. Creativity, as a comprehensive underpinning of complex understanding, however, presents a real danger of a dogmatic belief in the epiphany--a faith that complexity will melt away in the moment of intuitive realization. Creativity pushes understanding only so far, and then allows for the enlightened moment to occur. Creativity does not discern between right and wrong; its beauty is in the eye of the beholder. When the realization occurs that the pieces don't or aren't going to fit together into a comprehensive whole, the military theorist is again left with nothing but the "inshallah" approach.[25]

A creativity-based operational art implies a confidence in the superior creative ability of the US military, but how is creative success judged? Was the US more creative than its adversary on 9-11? Since the introduction of creative operational art into joint doctrine in 2006, have forces in Afghanistan and Iraq adapted more quickly and creatively than insurgents? History is replete with examples of creative genius: Lee at Chancellorsville, Patton in Europe, or MacArthur at Inchon. But history, particularly recent history like Operation RESTORE HOPE, Operation ENDURING FREEDOM, and Operation IRAQI FREEDOM, contains underwhelming evidence of understanding of one's environment as well. The most threatening consequence of faith in creativity is the

[25] As noted earlier, the literal translation of "inshallah" means "God willing." In the context of attempting to make order out of chaos with no theoretical underpinning, it is intended to convey the sentiment that pushing cognitively further in pursuit of understanding will quickly lead to overwhelming confusion, at which point one would end the pursuit and express a *hope* or a *faith* that "things will work out."

potential to voluntarily suspend reason and accept cognitive ignorance, thereby inventing more palatable conclusions for failure.

Thomas Kuhn, describing the origins of a paradigm crisis, notes, "An apparently arbitrary element, compounded of personal and historical accident, is always a formative ingredient of the beliefs espoused by a given scientific community at any given time."[26] Today's military establishment is teetering on the edge of catastrophe based on the seemingly arbitrary appearance of Paret and Howard's *On War* in 1976, and the introduction of the paint-by-numbers analogy in 2006. The Clausewitz revival short-circuited the harder task of achieving relevant understanding, while the concept of creativity became a panacea and a cure-all for the inability to make some sort of coherent picture out of the fragments. As Kuhn notes, events such as these are often the foundation of a paradigm crisis--not the most efficient or effective solution, simply a conglomeration of myriad historical elements colliding. The Paret and Howard translation appearing on the scene when the military was searching for salvation is an unfortunate event, not the proximate cause of this failure to think. The establishment would have found its savior in one form or another. The tragedy of Clausewitz is that military officers mistook historical reverence with modern relevance.

The Garden of Carl

Up to this point in the journey of Euclidain exploration, the environments framed have been static. They represented a single instance without consideration of how the environment changes. A brief introduction to change, without becoming bogged down just yet in the nature of change, is required at this point, both for academic pursuit and to

[26] Kuhn, *The Structure of Scientific Revolutions*, 4.

best represent the characteristics of today's environment. So, as reality pixelates before the reader and he finds himself in the mind of *a priori* man dropped magnificently from a time capsule into the Clausewitzian garden, the exploration begins one final time:

> If we consider other activities connected with the soil–gardening, for example, farming [and] building . . . , none extends to more than a very limited area, and a working knowledge of that area is soon acquired. But a commander must submit his work to a partner, space, which he can never completely reconnoiter, and which because of the constant movement and change to which he is subject he can never really come to know.[27]

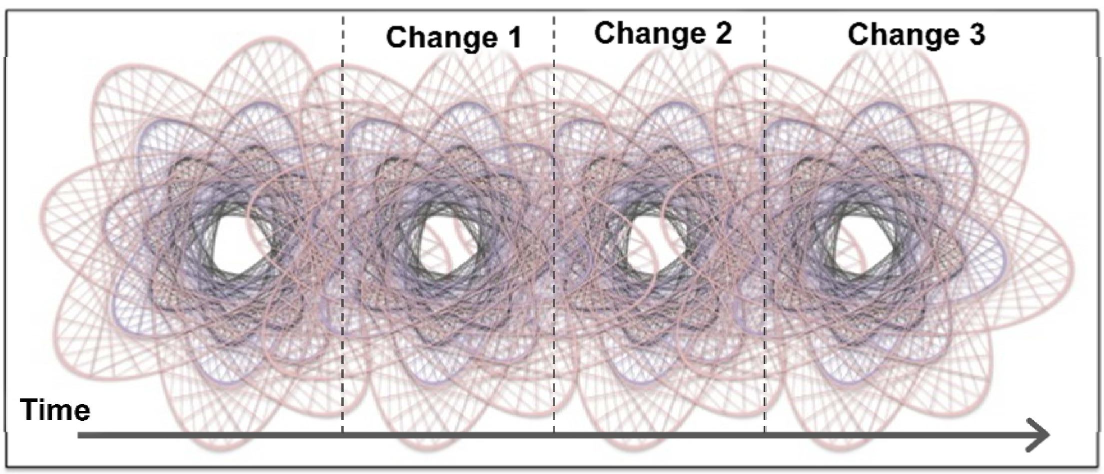
It can readily be seen from Clausewitz's metaphor why linear thinking had to end. Anything the commander once knew with certainty quickly fades into uncertainty and ambiguity as the battlefield expands and the opportunity for change pulls from a broader set of variables. The dynamic complexity of the environment demands a different level of understanding.

Figure 3-2 represents four instances of the cognitive environment, distributed proportionally from left to right. Proportional change, though, is artificial. If the world unfolded in events evenly distributed over time, one would simply have to measure the time between two events to know precisely when the third event would occur. Proportional change is linear and simplistic, far from characteristic of a real world environment. Yet even in this artificially simplistic model, four instances of a Euclidean-framed environment quickly decay into change that appears irrational and unpredictable, and for good reason.

Recall from Figure 3-1 that there are 384 individual line segments in a single instance of the 3-level environment. It follows that in Figure 3-2 there are 1,152 line segments representing a relational value between two observations, and 4,096

[27] Clausewitz, *On War,* 109.

intersections of thought representing the convergence or conflict of ideas. If one were to understand just two instances of the environment, he would have to store values for the original cognitive environment, the new cognitive environment, and relational values to make sense of the change. In total, including the relational values for change, there are 9,856 data points required to understand this environment with minimal precision using linear framing. Each time the environment stands still to allow for accurate recording of all that is known, there still remain 384 unknown areas within the framed environment at each stop. The number of possible changes, intersections, and arrangements is again, practically infinite. The overwhelming potential of change is an observation from antiquity, troubling Clausewitz, as well as his predecessors and succesors, in



understanding the nature of war.[28]

Figure 3-2: Proportional Change[29]

[28] M. Mitchell Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York: Simon & Schuster, 1992), 38.The ancient saying, "You can never step into the same river twice," attributed to Heraclitus, illustrates the overwhelming nature of change. Different forms of "everything flows" have been used to describe the theory of Heraclitus, some attributed directly to him while others were used by subsequent scholars to summarize the philosophy. This particular version is as quoted by Waldrop.

[29] Figure 3-2 shows no additions or subtractions to the number or arrangement of line segments ordering knowledge. In reality, they are constantly created and destroyed, as will be shown in Part II of this thesis. See also Figure C-5: Complex Change, for a nonsymmetrical complement to Figure 3-2.

Today's philosophical warrior, General James Mattis, challenged the future force during an interview on the end of EBO: "We need disciplined and unregimented thinking officers who think critically when the chips are down and the veneer of civilization is rubbed off--seeing the world for what it is, comfortable with uncertainty and life's inherent contradictions and able to reconcile war's grim realities with human aspirations."[30] Human intelligence is nowhere near reaching certainty with prediction; there are simply too many variables with too little time to evaluate. There are superior ways of thinking, however, that can reduce uncertainty. General Mattis is absolutely correct–critical thinking requires comfort with uncertainty. However, the critical thinker cannot become complacent with uncertainty. He must seek to lift the fog of war with a deep understanding of himself and the environment. Faith in superior creativity is not enough; he must "strive to better understand the different operating variables that make up today's more complex operating environments" and "not retreat into a need for more information."[31] Part II of the Operational Calculus endeavors to lift the fog with a new way of thinking, without making time stand still in order to make sense of it all.

The Nature of Crisis

A final note regarding the nature of a paradigm crisis must be understood before introducing a new way of thinking. Thomas Kuhn, writing to the scientific community about paradigms of scientific knowledge and events leading to crises in these paradigms, anticipated the gravity of dogmatic belief by a group of ardent and passionate

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[30] Spencer Ackerman, "Tech Skeptic is Petraeus New Boss," *Wired* (July 2010), http://www.wired.com/dangerroom/2010/07/tech-skeptic-is-petraeus-new-boss/ (accessed January 21, 2012).

[31] Joint Forces Command, Memorandum: Effects Based Operations, 2.

practitioners. Kuhn shaped a potentially hostile intellectual environment with the following brilliant preface to his work:

> Where I have indicated skepticism, it has more often been directed to a philosophical attitude than to any one of its fully articulated expressions. As a result, some of those who know and work within one of those articulated expressions may feel that I have missed their point. I think they will be wrong, but this essay is not calculated to convince them. To attempt that would have required a far longer and very different sort of book.[32]

This thesis is intended to carry that same sentiment to the reader who may be among the many skillful and creative practitioners of military art. The argument will be made that the subtleties, nuances, and context surrounding today's creative and conceptually shallow operational art preclude any dangers of dogmatic belief. Kuhn's "philosophical attitude" may be perceived as an academic crisis, not an operational deficiency, and therefore less threatening to the military establishment. To those who make this argument--you have missed the point. It is precisely the danger inherent in subtlety, nuance, and context that threaten to explain away any semblance of complex understanding, whether in the classroom or on the battlefield. Subtle shades of grey lure the observer into believing there is no longer a difference between black and white; that any and all creative solutions lay within the realm of possible and the scope of acceptable. A nuanced environment belies simple understanding and induces a faithful call to the genius of the commander. Cultural and historical context befuddle the senses into denial of critical analysis in favor of idioms and axioms--the "inshallah" approach. For these reasons, the military establishment faces a looming cognitive crisis, and requires a new way of thinking.

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[32] Kuhn, *The Structure of Scientific Revolutions*, xii.

PART II: A NEW WAY OF THINKING

Part I of the Operational Calculus described the current cognitive crisis in military affairs and its origins in the reincarnation of Clausewitz in 1976. The conditions post-Vietnam left the military establishment seeking answers with the fragments of a collective mental model in-hand. Senior military leadership at the time felt that change was occurring too rapidly for the military to fully comprehend.[1] Euclidean geometry had outlived its usefulness as a cognitive method, yet no new method of analysis was introduced to deal with a rapidly changing, complex environment. The cognitive tools left to the practitioner were an out-of-fashion geometric approach, and Clausewitz's "fog and friction" presented as the antithesis to prescriptive warfare.

Part II introduces the Operational Calculus to the reader as a cognitive method to deal with continuous, nonlinear change in complex environments. Just as Newton had to develop the analytical method of calculus before indulging further in the study of the physical world, the military theorist also needs a nonlinear cognitive framework to comprehend a post-Euclidean world. If one is to demystify the "creative genius" of operational art, change and a theory of change will be the foundation of a new way of thinking. There are no shortcuts--no elegant simplicity or appeal to the least of men. The military thinker must truly think. He must embrace the challenge of change with the ambition of an intellectual giant, removing self-limiting barriers to understanding. Part II of the Operational Calculus will not reduce the expanse of the military universe into

[1] Benson, "Educating the Army's Jedi," 4. Benson is writing about conclusions drawn by Wass de Czega, and the need for a new curriculum to educate Army officers.

twelve simple principles.[2] On the contrary, it will expand the horizons to understand the infinite and the infinitesimal of change.

Chapter 4: Dynamic Complexity

As a complex world changes with ever-increasing frequency, it takes on an inherent characteristic of dynamic complexity. Dynamic complexity is an environment of fluid motion driving towards constant change. This chapter shows the dynamic complexity of a changing nature of order and disorder. The cognitive model used to order one's environment, individually or collectively, increases in complexity as more cognitive environments are connected through an expanding awareness. Naturally, all of the segments of order, physical or metaphysical, do not conform to the existing state of order. As a new state of more or less order emerges, the tension between creation and destruction transforms into the fluid motion of change as a function of time.

A Flat World

The last chapter talked about simplistic, proportional change within the bounds of a limited environment; that environment is far from realistic. Figure 3-2 began to show change, but in a very limited scope. Cognitive awareness long ago surpassed the immediate physical environment, extending beyond the horizons to incorporate a vast plane into consciousness. In *The World is Flat,* Thomas Friedman wrote about the expansion of awareness with globalization, using the idea that a flat world essentially has no horizons. In a flat world, awareness encompasses the entirety of the globe. Friedman said, "The world is being flattened. I didn't start it and you can't stop it, except at a great

[2] See Joint Chiefs, *Joint Publication 3-0: Operations*, A-1 for the Principles of Joint Operations.

cost to human development and your own future."[3] Friedman was writing about a global environment with ever-increasing intersections of ideas, as many domains expand and overlap, essentially creating one singular flat world with layers upon layers of intersecting interests.[4] In fact, when taken to its broadest interpretation, a flat world brings all the total collective cognition upon a single point--every single point, at every single instant. The world is not completely flat just yet, though. The connectivity varies in different regions by choice or by circumstance, but it is certainly becoming more connected by the day, and as a result, more flat.

In a flat world, change comes frequently. Figure 4-1 illustrates Euclidean framing in an environment of frequent change, with the temporal sequence seen as moving from left to right in the figure. The multi-dimensional geometric scoping of the environment changes as awareness expands with change so frequent that it defies old models of periodic, stop and start change. Thoughts once held with certainty for generations are dramatically altered by the intersection of cognitive segments from a vast awareness. In today's world, as described by Friedman, a man in India could be wearing a Dallas Cowboys hat made in China while drinking Colombian coffee from a Seattle-based company.[5] In Egypt, men ride donkeys pulling carts in the shadow of ancient pyramids while men on smart phones in European luxury cars squeeze past in narrow streets.[6] The illustration brings the maddening cacophony of myriad variables crashing upon any remaining semblance of rational thought left to the Euclidean approach. There are simply

[3] Thomas Friedman, *The World is Flat* (New York: Farrar, Straus, and Giroux, 2005), 469.

[4] See also Thomas Friedman, *The Lexus and the Olive Tree* (New York: Farrar, Straus, and Giroux, 1999) or A. G. Hopkins, ed., *Globalization in World History* (London: Pimlicon, 2002) for in-depth looks at the effects of globalization.

[5] Ibid., derived from Friedman's work, though not an actual example.

[6] Author's personal experience.

too many points, line segments, intersections, and areas to untangle without the luxury of stopping every instant. The frequency of change is too great for the old methodology.

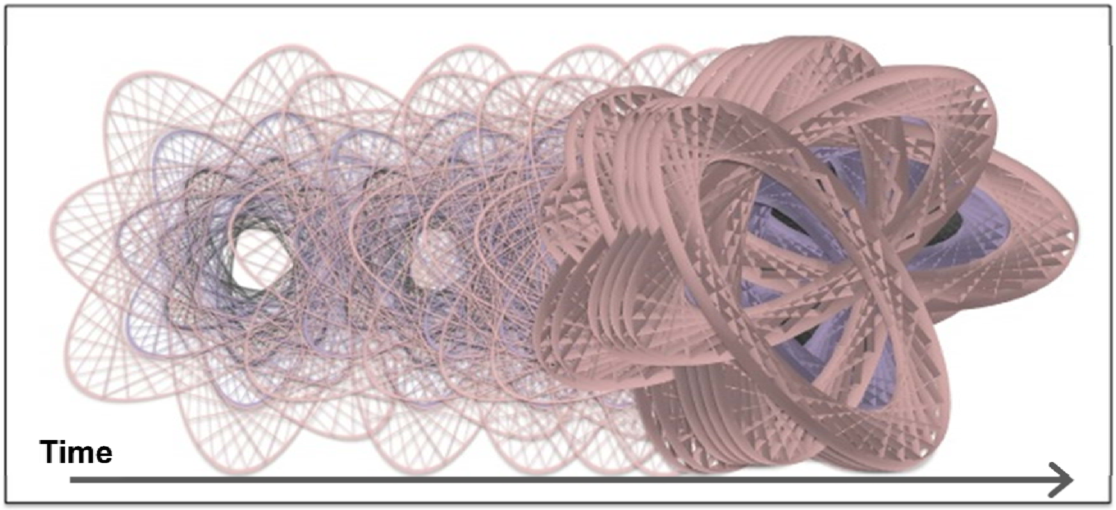

Figure 4-1: Dynamic Complexity

Almost two hundred years ago, Clausewitz noted with concern the "constant movement and change" of the environment. To explain the uncertainty in cognition induced by frequent change, he included the element "chance" in his Trinity.[7] He recognized that the further he extended the space, or the boundaries, of the working knowledge, the more the number of variables constituting the details of that space grew. As the number of variables grew it became more likely that one of these variables would change in a way to have significant impact upon the whole of warfare. Additionally, as the cognitive awareness expanded outward the areas of uncertainty were ever-increasing. The environment was not just complex; it was becoming dynamically complex.

Dynamic complexity is characteristic of an operational environment that Joint Publication 1, *Doctrine for the Armed Forces of the United States*, describes as "complex, interconnected, and global," or a strategic environment that Yarger describes as

[7] Clausewitz, *On War,* 89.

"increasingly complex" and "rapidly changing."[8] A century before Clausewitz, Isaac Newton developed an analytical method to understand such rapid change. The method was the derivative calculus, put forth in the first book of the *Principia* by Newton in 1687 as the theoretical underpinning of the laws of motion Newton established.[9] Michael Guillen describes the origin of Newton's method for understanding change:

> The only certainty in this world, as the saying goes, is change, and everything we learn from science bears this out. The contents of the universe and the universe itself are in an implacable state of flux. Things that appear constant--mountains, the atmosphere, the sun--are in fact constantly sustaining enormous changes of being; they are in an active state of balance . . . in a dynamic world such as ours, it is inevitable that scientists require a mathematical means with which to study change, and it was mainly in response to this scientific need that Newton invented the calculus. He designed it to describe changes that proceed in small, continuous steps.[10]

The "implacable state of flux" is characteristic of the complex awareness informed by Friedman's "flat world." A near-infinite number of cognitive segments merge together in the cognitive bounds of a military establishment charged with global responsibility. The change is constant--but what, exactly, do words like "constant" and "continuous" mean in terms of change? Further still, what is the nature of change?

A Single Point

An additional conceptual point regarding complexity requires clarification before moving onto continuous, dynamic change. Figure 4-1 shows the rapidly changing cognitive framing of the environment where the rate of change is not constant, but

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[8] Joint Staff, *Joint Publication 1,* I-6; Harry Yarger, *Strategic Theory for the 21st Century: The Little Book on Big Strategy* (Carlisle, PA: US Army Strategic Studies Institute, 2006), vii.

[9] Stanford Metaphysics Research Lab, "Newton's *Philosophiae Naturalis Principia Mathematica,"* (Stanford University: Stanford Encyclopedia of Philosophy, 2007), http://plato.stanford.edu/entries/newton-principia/ (accessed January 22, 2012).

[10] Guillen, *Bridges to Infinity*, 163.

increasing. To understand change within the bounds of human perception, normally change is considered as contrasted to time; in other words, a change is measured against time. If all of the intricacies of Figure 4-1 are considered changing with every instant, and the entire complexity compressed down upon a single theoretical point, then the dynamic complexity of the collective body of human knowledge can be understood as a single point relative to a single instant. Expansive fragments of understanding--or even formed and framed sets of knowledge--from myriad perspectives are thrust upon the consciousness of an observer whose horizons of awareness have been removed by a flat world. Instead of *a priori man* standing and storing cognitive data from the extent of his sensory observation, modern man, both individually and collectively, copes with a vast, and growing, awareness of exponential knowledge free from traditional barriers of language and distance. The connected set of knowledge solidifies around a core of compressed, densely concentrated ideas thrust together in time and space. The result is a collective cognitive model of consolidated and condensed perspectives held with more or less certainty by each individual.

Figure 4-2 illustrates the compression. At any instant, the point representing the body of knowledge (or collective human cognition) can be understood more thoroughly by its relationship to time.[11] The entirety of the collective cognitive data points is brought to bear on a single instant of consciousness from near infinite dimensions. Each data point is connected with a relational segment, segments ordering environments with

[11] Collective cognition is that an understanding develops outside of any singular perspective but representative of the whole. For example, the cognitive cognition of the US political environment is the common understanding that conservative perspectives view the world one way and progressives in another way, with myriad shades in between the two poles. Collective cognition is the state of cognition that exists objectively inclusive of all perspectives. Credit for the term "collective cognition" is due to discussions with peers highlighting the difference between "group think" and a collective consciousness or cognition.

known and unknown areas, and environments framing new environments. Fragments remain from previous cognitive models and intersect the theoretical cognitive point from an infinite number of directions from an infinite number of planes, leaving a solid state of awareness existing at an instant in time. So, with a single point of consciousness established, the reader is able to move to the question of the nature of constant change.

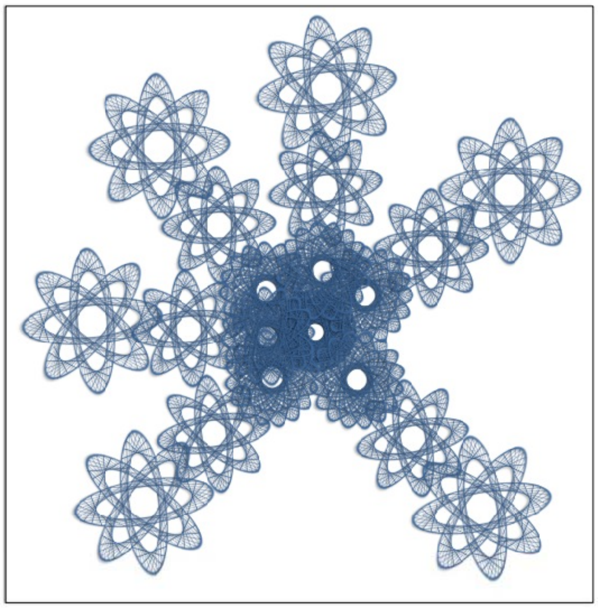

Figure 4-2: Merging Cognitive Domain

Continuity of Change

Aristotle defined change as consisting of three species: generation, destruction, and motion. He further defined generation as “a change from not-being to being” and destruction as a “change from being to nonbeing.”[12] Constant change, in Aristotle’s terms, is a never-ending stream of destruction and generation, much like the cognitive model changing every instant. In fact, Aristotle concluded, “Motion is thought to be one

[12] Hippocrates Apostle, trans., *Aristotle’s Physics*, (Grinnell, Iowa: The Peripatetic Press, 1980), 352.

of those things which are continuous, and it is in the continuous the infinite first appears."[13] The infinite, as well as the infinitesimal are the foundations for understanding all of Aristotelian and Newtonian motion of change. Motion traditionally has been reserved for the study of physical bodies, most widely associated with mechanics. The college physics student is taught to establish an initial position of an object through empirical observation, then measure the change in the object's position on a predetermined scale, and divide the measurement by a unit of time to find the average rate of change of the object. However, it is worth relooking the conventional association of the concept of motion to the purely physical domain.

The Santa Fe Institute's study of complexity is among the emerging sciences that allow the crossover of motion from the physical to the ideological domain. Complexity theory asserts that complex life forms exist on the edge of chaos, and, in fact, life itself emerges from the self-limiting complexity constantly undergoing "phase transition" between order and chaos.[14] Mitchell Waldrop writes about the evolution of Complexity Theory and the beginnings of the Santa Fe Institute in his book, *Complexity--The Emerging Science at the Edge of Order and Chaos.* Waldrop tells the story of Chris Langton, a computer scientist at Santa Fe who coined the term, "Artificial Intelligence," applying the "edge-of-chaos" phase transition to cellular behavior. Langton asserts that the "mysterious something that makes life and mind possible is a certain kind of balance between the forces of order and the forces of disorder. More precisely, he's saying that you should look at systems in terms of how they behave instead of how they're made."[15]

[13] Ibid., 42.

[14] See Ricard Sole, *Phase Transitions* (New Jersey: Princeton University Press, 2011).

[15] Waldrop, *Complexity,* 293.

The behavior of the system is the motion of the collective change of the whole complex cognition over time, rather than understanding billions of cognitive data points and line segments.[16]

Complex systems behave the way they do based on an initial set of rules and an adaptive, evolutionary process of destruction and creation. Something lives and something dies. "Adaptive" and "evolutionary" imply changes in behavior as contrasted against a scale of time. Change in the state of order and disorder, generation and destruction, being and not being assimilate into a pattern of tension over time. That behavioral pattern is motion: motion of a physical body, or motion of a complex set of ideas. Both physical and ideological motion is a flipbook of instant cognitive models. Taken out of context one single sketch of reality would give no practical bearing of the motion of the whole. As pages are flipped with increasing frequency, the change transforms from a set of individual snapshots to fluid motion. Motion is change. The pattern of change over time is a function--a pattern determining the relationship between the set of cognitive knowledge and time. The change in a complex system can thus be seen, and analyzed, as a nonlinear function of time.[17]

Cognitive complexity is descriptive of the number and interconnectivity of ideas. In his book *The Logic of Failure*, Deitrich Dorner defines complexity as "the label we

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[16] Stanford Metaphysics Research Lab, "Ernst Mach*,"* (Stanford University: Stanford Encyclopedia of Philosophy, 2007), http://plato.stanford.edu/entries/ernst-mach/ (accessed February 15, 2012). Mach, as a physiological psychologist, argues for the merging of metaphysics and physics into a single construct, though not with complexity theory. Mach uses Lorenz transformative equations to show a quantitative relationship between physics and metaphysics. This thesis will show only qualitative relationships.

[17] Several authors, including Tom Czerwinski, Coping with the Bounds: Speculations of Nonlinearity in Military Affairs (National Defense University, Institute for National Strategic Studies, Washington, DC, 1998) and Alan Beyerchen, Clausewitz and Nonlinearity (http://clausewitz.com/readings/Beyerchen/CWZandNonlinearity.htm#2) discuss the nonlinearity of war.

give to the existence of many interdependent variables in a given system." He goes on to say "a system of variables is "interrelated" if an action that affects or is meant to affect one part of the system will also affect other parts of it."[18] In a flat world, they are all connected. Part I of this thesis mapped the cognitive complexity from a single thought through billions of points, lines, and areas. In some way or another, every thought is connected. Even the most remote and distant thought has a relational value to other thoughts--just by recognizing that it is remote from the rest of cognition one assigns that thought connectivity to the whole. Any change in one variable affects the whole, if only minimally. As these lines of cognition interact to form novel values or shape previously unknown areas, they create change in the total order and disorder of the individual, or collective, cognition. The behavior of the complexity is change, and that change is motion. The analytical method first used by Newton to study the motion of celestial bodies is the same method used to study the change of complexity. Planets are, after all, just a complex system of creation and destruction. Their motion is fully predictable, not chaotic and unpredictable.[19]

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[18] Deitrich Dorner, *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations* (New York: Metropolitan Books, 1996), 38.

[19] The terms nonlinear, chaotic, complex, and unpredictable are often confused. Those terms may be representative of a broader commonality, as described by Beyerchen, "Like other members of a large class of terms, "nonlinear" indicates that the norm is what it negates. Words such as periodic or asymmetrical, disequilibrium or nonequilibrium are deeply rooted in a cultural heritage that stems from the classical Greeks." However, there is significant distinction among them. Many nonlinear functions are fully predictable. Complexity theory says that change is a constant "phase transition" between order and chaos, but that complexity is not the same as chaos. Complexity throughout this work means precisely "the number and interconnectivity of variables."

The Complex Human Dimension

War is a system of complex systems, and chief among those complex systems are the human minds that make the decisions of war.[20] Noted authors Waldrop, Gladwell, Gonzalez, and Dorner recognize the complexity of the human mind in their work. Niall Ferguson, in "Complexity and Collapse: Empires on the Edge of Chaos," writes of the "enchanted loom" of the human intellect: "Human intelligence itself is a complex system, a product of interactions of billions of neurons in the central nervous system."[21] Ferguson goes on to say, "The political and economic structures made by humans share many of the features of complex adaptive systems."[22] The interaction of billions of neurons is exactly what this thesis means by dynamic complexity. The neurons function to create a complex set of ideas that in turn create human systems like politics, economics, and war.

In their study, *Theory and Methods for Supporting High Level Military Decision Making*, Paul Davis and James Kahan make the transition to decision-making in a complex wartime environment. Davis and Kahan talk about continuous change affecting military decision-making and note that, "the changes to be understood may be almost continuous, each so small as to be barely perceived, or they may be discrete events." The authors further postulate that these drivers of change "are rarely fully predictable" and any military decision-making theory must consider "attitudes about uncertainty and the

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[20] See Joint Chiefs, *Joint Publication 3-0: Joint Operations*, IV-4. "One way to think of the operational environment is a set of complex and constantly interacting political, military, economic, social, information, and infrastructure (PMESII), and other systems." This thesis does not draw the distinction between interacting complex systems and non-interacting complex systems, as complexity by definition includes both the interaction and numeracy of variables.

[21] Niall Ferguson, "Complexity and Collapse: Empires on the Edge of Chaos," *Foreign Affairs* 89, no. 2 (March/April 2010): 22.

[22] Ibid.

feasibility of achieving control over complex, adaptive human systems."[23] Finally, Davis and Kahan recognize with keen insight that "Air Force officers are inclined intuitively toward the image of imposing control on a system, whereas ground-force officers are more inclined toward humility and constant reference to the fogs and frictions of war."[24]

In a sense, the ground-force officer is fully immersed in the complex mess at the edge of chaos, a sort of point-man for the spread of order. He witnesses firsthand, as did Clausewitz and Mattis, the irrationality, unpredictability, and uncertainty of chaos.[25] The military officer is a disciplined, ordered being wishing to impose control and order on his environment. The constant interaction of success and failure, of creation and destruction, of life and death--the fluid motion of complex change--denies his efforts.

Rick Rowlett, a senior joint doctrine writer at the Joint Warfare Center in Suffolk, Virginia, relayed his oft-shared observation that joint doctrine has been very much dominated by ground-force doctrine. Rowlett noted, "It [the doctrinal process] is a very Army and Marine Corps-centric process."[26] It is no surprise then that Joint Publication 1 characterizes the nature of war from a chaotic perspective: "War is a complex, human undertaking that does not respond to deterministic rules."[27] The perception is correct--

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[23] Davis and Kahan, *Theory and Methods for Supporting High Level Military Decision Making*, 34.

[24] Ibid., 64.

[25] Further complicating the perspective of a ground-force officer is a limited understanding of Chaos theory. Chaos theory says that there exist a very small number of variables whose response to a change in initial conditions produces a disproportionate effect on the whole over time. The opinion of this author is that Chaos theory is subordinate to Complexity – there are instances where a seemingly harmless action causes widespread disorder; however, those instances are a function of the entire state of order and disorder of the system, not the action of the individual. In either case, those instances are far from the norm, and should not lead the ground-force officer to believe that he is operating in complete chaos. See Annex A, "More than Academic," for discussion of parameters of behavior at the tactical level.

[26] Rick Rowlett, Interview with Author, Suffolk, VA, January 7, 2011.

[27] Joint Staff, *Joint Publication 1*, I-1.

war does not follow deterministic rules, but it does follow a macro pattern of change that has relational rules deeply rooted in mathematical principle. "The misperception is that mathematics is antiseptically rational and therefore has little or no relevance to the characteristically irrational activities of human beings."[28] The behavior of complex systems, including human systems, is the motion of change, regardless of how those systems are made.

Consider the analogy, not of human psychological behavior, but of the pure physiology of the human body. At the time of this writing, modern medicine is far from understanding all the ailments that could potentially affect the human body, and therefore the lifetime physical health of an individual is very much unpredictable on the micro level. It is assumed that all maladies will not be solved in the near future. However, if medical practitioners, genetic researchers, or medical-science theorists attributed all uncertainty in their tradecraft to the irrationality of being human, then modern medicine would consist of witchcraft and alchemy. Fortunately they do not. Researchers interested in the physiology of life continue to push toward greater clarity of understanding and create and destroy models of understanding as they move forward.[29]

The astute reader will naturally conclude that there is more to life than the micro-level behavior of cells--if it were that simple geneticists would have uncovered the formula to turn protein into life long ago. However, the changing behavior *is* science written with the language of math. The science of complexity transcends the domains of

[28] Guillen, *Bridges to Infinity*, 6.

[29] See as example: Futurity, "Math Model Predicts Cell Behavior," http://www.futurity.org/science-technology/math-model-predicts-cell-behavior/ (accessed February 15, 2012). Researchers at New York University predict cellular behavior based on a mathematical model of behavior, not an investigation into how the cells are made.

human behavior and human cognition: "Here was a whole messy world–the interior of a living cell, that was at least as complicated as the human world, yet it was science . . . . This messy, organic, non-mechanistic world was in fact governed by a handful of principles that were as deep and profound as Newton's laws of motion."[30]

To those eager to dismiss the merits of complexity theory, it should be noted that Erwin Schrödinger, who is most widely known as a co-founder of quantum mechanics, shared the same philosophy of complex human behavior taking a governed form of life well before Complexity Theory came to light.[31] Schrödinger wrote a brilliant but little known essay in 1944, titled, "What is Life", in which he insightfully predicted laws governing cellular recreation based on physical and chemical observation. These laws would eventually emerge as modern genetics. Schrödinger declared: "How can the events in space and time which take place within the spatial boundary of a living organism be accounted for by physics and chemistry? The obvious inability of present-day physics and chemistry to account for such events is no reason at all for doubting that they can be accounted for by those sciences."[32] Schrödinger also noted the change and motion characteristic of complex life. When "all motion comes to a standstill" the complex life form quickly decays into an Aristotelian state of "non-being," and that life itself was "eating, drinking, breathing, and assimilating. The technical term is metabolism. The Greek word means change or exchange."[33] The billions of cells that constitute an individual human life are based on complex change and exchange–

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[30] Waldrop, *Complexity*, 30.

[31] See Walter J. Moore, *Schrödinger: Life and Thought* (Cambridge: Cambridge University, 1992).

[32] Erwin Schrödinger, "What is Life?" http://whatislife.stanford.edu/LoCo_files/What-is-Life.pdf (Original Lecture 1944, accessed October 13, 2011).

[33] Ibid., 26.

interaction on the physical and metaphysical level with other elements. The result is a continuous pattern of motion.

The complex pattern emerges yet again: change and motion. The human domain, be it physical or metaphysical, is not exempt from the rules of the universe. Those exceptional humans who have climbed to the pinnacle of the military profession are subject to the laws of the universe, as are their opponents. The give and take between them, the creation and destruction, become the motion of the instantaneous state of order and disorder. Admittedly, it is not simple, linear motion, but it is motion nonetheless, and motion has laws. When these changes from the human domain merge with a near infinite number of changes from every domain at every instant in the cognitive awareness, constant, continuous, fluid motion emerges. An instant, solid state of cognitive awareness (individual or collective) of the state of order and disorder will be explored below as the body of knowledge.

The Body of Knowledge

Boyd, in his briefing, "A Discourse on Winning and Losing," also saw the potential to study warfare through the lens of physical change, as he applied the second law of thermodynamics to fighter pilot tactics to create his "conceptual spiral" and eventually his Energy Maneuverability (EM) theory.[34] As Boyd analyzed the way the warfighter thought and made decisions, he developed the EM theory further than the maneuverability of a physical object.[35] The result in the military lexicon today is Boyd's famous Observe, Orient, Decide, and Act (OODA) decision cycle model. The theoretical

[34] Boyd, "A Discourse on Winning and Losing."

[35] Coram, *Boyd. The Fighter Pilot who Changed the Art of War*, 337.

foundation of the OODA loop lies in one of Boyd's unpublished works, "Destruction and Creation." In it, Boyd describes the cognitive process of developing a mental model through a rapid process whereby an existing model is destroyed and a new model is created. The creation occurs either by a reordering of the components of the model or by the introduction of novel concepts into the framework of understanding.

> To comprehend and cope with our environment, we develop mental patterns or concepts of meaning . . . we destroy and create these patterns to permit us to both shape and be shaped by a changing environment. The activity is dialectic in nature generating both disorder and order that emerges as a changing and expanding universe of mental concepts matched to a changing and expanding universe of observed reality.[36]

The magnitude of the change, and thereby the revolutionary or disruptive potential, depends upon how expansively the previous model was changed. Not all cognitive relationships are destroyed; in some cases a new segment is simply added onto the existing complexity with little impact other than to expand the understanding of the cognitive environment. In other cases, the set of cognitive data requires wholesale change because the current model does not support the newly introduced data. It simply doesn't comport with perceived reality, but cannot be ignored any longer. Survivability, to Boyd, depended upon adaptability along with speed and accuracy in developing a new model upon interaction with the environment. "Interaction permits vitality and growth, while isolation leads to decay and disintegration."[37] Physical and metaphysical life is change, and change exists on the edge of order and chaos where the continuous interaction of destruction and creation result in the fluid motion of change.

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[36] Boyd, "Destruction and Creation," 1.

[37] John Boyd, "The Strategic Game of ? and ?" http://www.dnipogo.org/boyd/pdf/strategy.pdf (accessed February 14, 2012).

To study the motion of change, a system of ordering must first be established. In 1997, then-Army Major Joseph Brendler wrote a monograph for the School of Advanced Military Studies (SAMS) concerning the role of information theory in the ordering of thought. Brendler described classic information theory as an "ordering in space and time to represent the ordering of something else."[38] Brendler attributed the origins of his thought process to Douglas Hofstadter's work, *Gödel, Escher, Bach: An Eternal Golden Braid*, a work in which Hofstadter combines music, math, and symbols to demonstrate how words and sets of words can take on meaning despite their intended use.[39] "When a system of 'meaningless' symbols has patterns in it that accurately track, or mirror, various phenomena in the world, then that tracking or mirroring imbues the symbols with some degree of meaning--indeed, such tracking or mirroring is no less and no more than what meaning is."[40]

This entire "system" of understanding is the "something" that is ordered in space and time--the whole of cognition and meta-cognition, of physical observation and metaphysical observation. The "something" is the entire set of data used to order the environment. Brendler considered this "something" a collective "body of knowledge" which is, "a collective set of cognitively justified beliefs. The actor assesses the relevance of these beliefs, perceives and distinguishes relationships between elements of

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[38] Joseph Brendler, "The Stuff that Binds: On the Nature and Role of Information in Military Operations," (School of Advanced Military Studies Monograph, US Army Command and General Staff College, Fort Leavenworth, KS, AY 1997-1998). At the time of this writing, Brendler is an Army Brigadier General and the Chief Information Officer for the International Security and Assistance Force (ISAF) Afghanistan.

[39] Joseph Brendler, email exchange with the Author, December 12, 2011.

[40] Douglas Hofstadter, *Gödel, Escher, Bach: An Eternal Golden Braid* (New York: Basic Books, 1979), 3.

knowledge, and draws more conclusions by comprehension and analysis."[41] One point is connected to another to form an element of knowledge, the segment of knowledge is related to another segment of knowledge, and the analysis of multiple segments of knowledge leads to further conclusions as to the whole of "cognitively justified beliefs."[42]

The body of knowledge, then, exists at a point arranged in space and time. Space, in the sense of cognition, is the infinite expanse of order and chaos, as illustrated in Figure 4-3. The line between perceived order and perceived chaos is the motion of creation and destruction of a cognitive model on a grand scale. Cumulative knowledge is the ordered area under the curve, to be discussed in Chapter 5 in the "Area Problem." The instantaneous position of the state of order and disorder, in the human cognition, is represented as $K_{B.}$ The entire set of the ordered line segments of *a priori* man, their intersections, their relationship to an environment, and their relationship relative to the previous model and to a desired future state of order, create the "something" that is a cognitive function of time. The body of knowledge, $K_{B,}$ is not order, and it is not chaos. The body of knowledge is a metaphysical body that exists along the cognitive phase transition of order and chaos and is representative of the condition of the collective cognition. The substance of the body of knowledge garners mass as collective perceptions merge in time and space.

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[41] Brendler, "The Stuff that Binds," 18.

[42] Recall in Chapter 1 of this work the growth of knowledge of the simple environment of *a priori* man, as well as the accumulation of knowledge of the physical domain through Euclidean methods, was described as, "The growth of military theory and doctrine, or the cumulative knowledge of any collective body for that matter, has progressed in the same way--accumulated observations known to be true from experience are used to prove, disprove, or discover other truths." The cognitive ordering is the same, whether in the physical or ideological domains. Because one does not discover "truths" in a proportional temporal manner, the cognitive ordering is not symmetrical and linear, but a conglomeration of different lengths and spacing.

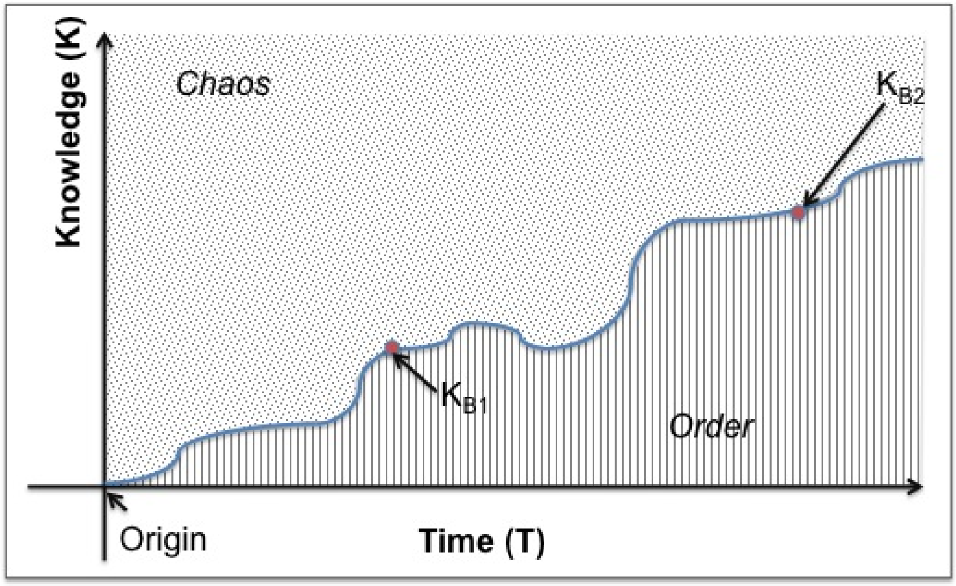

Figure 4-3: The Body of Knowledge[43]

The position of K_B is a qualitative theoretical concept introduced to understand relational motion of change. There is not a quantitative value assigned to the body of knowledge. It is a concept of position used to establish cognitive change as order and disorder flux over time. One value is dependent upon the previous value, so that no empirical absolutes can be established. This characteristic of position is described mathematically as Werner Heisenberg's uncertainty principle, which mathematically proved that "in order to predict the future position and velocity of a particle, one has to be able to measure its present position and velocity accurately."[44] In other words, every future position is tied to a current state of order and disorder, and to predict the future position with certainty requires that we know the current position with certainty.

The backwards leapfrog continues to well before human knowledge was recorded. For example, to understand today's environment, one would need to understand with

[43] The body, K_B, is the compressed complexity of Figure 4-2 with myriad perspectives and multiple levels of arranged at a single instant in a relative state of order and chaos. The blue line progressing along the boundary is the fluid motion built in Figure 4-1 with subordinate levels within.

[44] Stephen Hawking, *A Brief History of Time* (New York: Bantam Books, 1988), 56.

absolute clarity the strategic environment of Vietnam. Yet, to understand Vietnam, one would need to understand World War II, and to understand World War II one would need to understand World War I, colonialism, and the Industrial Revolution. The pattern repeats and uncertainty grows. Stephen Hawking summarized the consequences with, "one cannot predict future events precisely if one cannot even measure the present state of the universe precisely."[45] As Hawking suggests, space and time are determined by picking a point somewhere in the middle of it all and establishing relational values from there. The certainty of the space and time values of the original position increase with each relational value determined. Fundamentally, this concept is a qualitative "quantum" position.[46]

There is much practical value, though, in understanding a qualitative "quantum" position. Heisenberg, Schrödinger, and Paul Dirac proved that the confidence in the position of a particle increases as a function of the number of similar measurements taken on a large number of similar instruments. So, then, applied to a strategic environment, the more perspectives considered, the better the probability of understanding the nature of position and change within that environment. "A similar number of instruments" by which to measure would imply a number of collective bodies similar to the military establishment. In Hofstadter fashion, it is not coincidence that collective bodies of national power such as those charged with diplomacy or economic responsibility are

[45] Ibid., 57.

[46] See H.A. Lorentz, A. Einstein, H. Minkowski and H. Weyl, *The Principle of Relativity: A Collection of Original Memoirs on the Special and General Theory of Relativity,* W. Perrett and G.B. Jeffery, trans. (New York: Dover Publications, 1952), 157. Einstein states that the Newtonian equations of motion are a good first approximation, "but to that end, we still need to approximate the fundamental equations from a second point of view." This thesis will describe the motion of change using a first approximation, and will not discuss the mathematical methods required to incorporate considerations of Einstein's relativity.

considered instruments of power.[47] They are all charged with carrying out the power functions of the United States, and there exists a collective understanding of these bodies as strategic "instruments" of like output. The interagency process can be seen as a sort of quantum estimation of the strategic environment--multiple perspectives compared and contrasted to establish a strategic estimate. Quantum position also carries with it the dictum to consider the perspective of multiple nations and international organizations. A broad coalition of consensus is necessary not just because it balances risk and responsibility, but because it brings clarity and certainty to position. Although joint doctrine describes the interagency process as "more of an art than a science," it is not art, but science, underwritten with a nonlinear method of understanding.[48]

The Motion of Change

Stephen Hawking said, "What makes this universe interesting is that although the fundamental 'physics' of this universe is simple, the 'chemistry' can be complicated."[49] To know each and every "chemical bond" of observation and relation in the cognitive order is, at the moment, impossible. One can only hope to unravel a few threads of "why" and "because" within the collective body of knowledge. Yet what Hawking stated is also true for the study of dynamic complexity. While the "chemistry" is impossible, understanding the behavior of change is entirely possible. The motion of the collective

[47] Hofstadter, *Godel, Escher, Bach: an Eternal Golden Braid*, 375. Hofstadter explained how words develop isomorphic meaning based on the likeness of individual perception which transfers to a likeness in collective perception. For example, Hofstadter wrote, "My roads will not be exactly the same as yours, but, with our separate maps, we can each get from a particular part of the country to another." The elements of power are given meaning based upon conscious and subconscious awareness of how they came to be considered power elements, and by the features of physical power they retain.

[48] Joint Staff, *Joint Publication 1*, XXI.

[49] Stephen Hawking and Leonard Mlodinow, *The Grand Design* (New York: Bantam Books, 2010), 175.

state of order and disorder creates macro patterns that follow laws described with (relatively) basic mathematics.

An important distinction in the direction of motion is the idea of path dependency. The motion of change takes on an inherent quality of path dependency, meaning that the qualitative value or impact of change depends upon perspective. Brian Green noted, "Whenever we discuss speed or velocity, we must specify who or what is doing the measuring."[50] The same holds true for the motion of change. The absolute value of change, when seen as motion, is the change in order and disorder divided by the change in time. It would seem that a greater value for collective knowledge (again, the state of order and disorder) is universally perceived as positive; however, that presumption does not hold true in a world where individuals or organizations seek to gain individual value at the cost of advancement of the whole.

Moreover, as was pointed out above, not all individuals see the state of order and disorder in the same perspective. There are winners and losers, and those who would perceive themselves to suffer from a "change" in the collective cognitive state of all of those distinct line segments and intersections would naturally resist accepting that change. Rarely does significant change of any sort receive universal acceptance. Even Aristotle, whose mind was far ahead of his contemporaries, "rejected the concept of atoms because he could not accept that human beings were composed of soulless, inanimate objects."[51] The change of destroying and recreating a cognitive model does not come without resistance; that resistance will be discussed further in the chapter on mass (Chapter 6).

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[50] Brian Green, *The Elegant Universe*, 28.

[51] Stephen Hawking, *The Grand Design,* 22.

On a grand scale, however, changes that bring about greater order and less chaos in the world can be seen as positive, and those destroying order and bringing about more disorder can be seen as negative. The path of the motion of change in a direction that creates order out of chaos is assigned a positive qualitative value, and the path of motion in the direction that destroys order is given a negative value. Building on Figure 4-3, Figure 4-4 illustrates change as a function of time. The average value of the change is equal to the total change in the position of the body of knowledge (ΔK) divided by the total change in time (ΔT). Time, in this sense, is seen as continuously moving forward, and therefore always retains a positive value. The qualitative (positive or negative) value of change is the same qualitative value of knowledge.

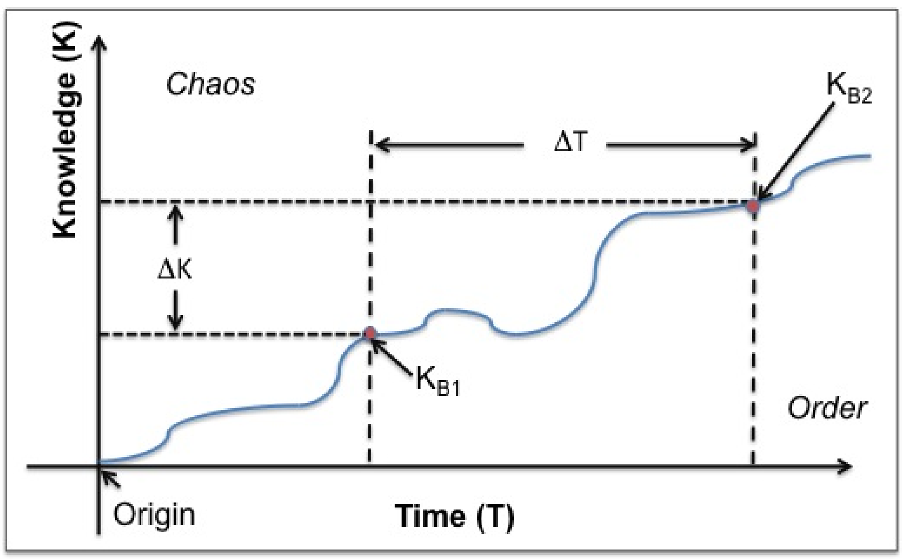

Figure 4-4: Qualitative Change

Since $\Delta T = T_2 - T_1$, and $\Delta K = K_2 - K_1$, then average rate of change, as a function of time, is expressed as:

$$f(t) = \frac{K_2 - K_1}{T_2 - T_1}.$$

To be clear, this is not a physical metaphor for change. This depiction of qualitative change is an observation of reality, not a comparative example. Guillen explained, "Mathematical ideas turn out to be realistic as often as they do because they are not merely inventions, but observations."[52] The observation of average change, however, holds little practical value in Friedman's flat world where change is continuous.

The average change function described above is a linear function, and to demonstrate why linear approximations distort understanding, consider Figure 4-5. The average change function is plotted against the actual change function from the original position of the body of knowledge to the ending position of the body of knowledge. The distance between the average function value and the real value of change, shaded in red on the figure, is the instantaneous uncertainty of one's position. Depending upon the timescale, those areas of uncertainty can hold a whole host of surprises.

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[52] Guillen, *Bridges to Infinity*, 4.

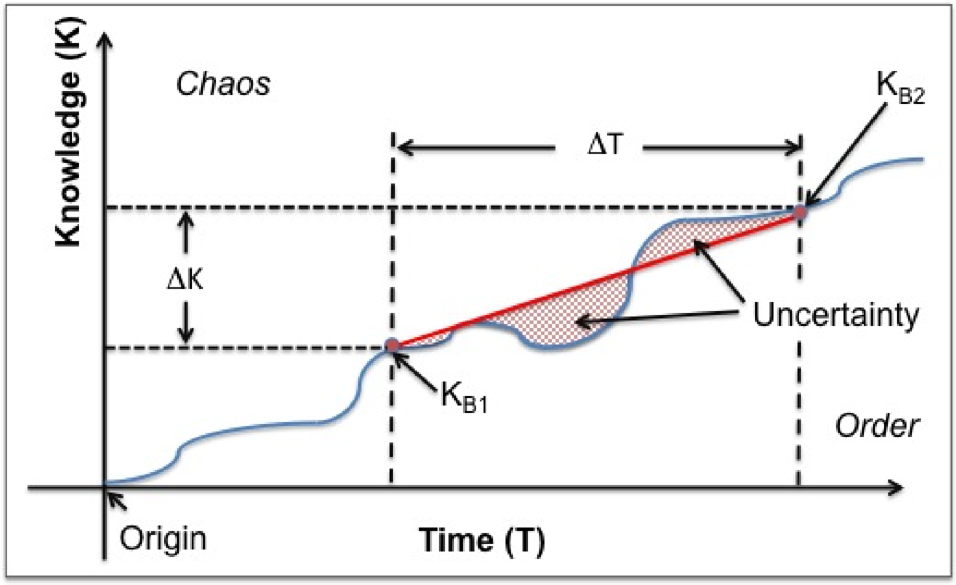

Figure 4-5: Average Rate of Change

If a time span of 10 years were chosen, for example, covering the period of 2003-2012, the entire insurgency in Iraq would have been misjudged by linear approximation, and at any given point the intensity of the insurgency would have been gravely misunderstood. A decision-maker looking forward from 2003 could have seen an eventual end-state that consisted of some sort of Iraqi self-rule, but if he were thinking linearly he would not have seen the vicious cycles of creation and destruction, order and chaos hidden in the areas of uncertainty. An historian, looking backwards from 2012, would draw several approximations using a linear function and would realize that observed reality did not match his approximations.

Summary

Without a better method of analysis, it can be understood why the military establishment turned to creative solutions. First, the complexity of the whole is too much for the Euclidean framework to bear. The collective cognition seemingly descends into chaos as man is continuously overwhelmed by the complexity and pace of physical and metaphysical change around him. Even for those with an "iron will" to bear the uncertainty, the frequency of change dominates and destroys static understanding.[53] Friedman's flat world brings previously isolated and distinct environments crashing onto a single point at every instant. Finally, predictions and expectations prove false time and again with linear methodology. Too much time is spent analyzing the "chemistry" of the components, and too little time analyzing the behavior, or motion, of the whole.

This chapter transformed complexity into dynamic complexity, and showed that a state of awareness exists, individually and collectively, along the edge of order and chaos. Cognitive segments and areas, varying in number, are added or removed from the whole of cognition to produce a new state of order and disorder every instant. As this state is viewed over time, the patterns of the motion of change appear. The patterns emerging from dynamic, complex behavior can be viewed as a function of time and the basis of a nonlinear cognitive method. The next chapter shows exactly why this understanding is not art, but calculus.

[53] Clausewitz, *On War*, 119. Clausewitz said, "Iron will-power can overcome this friction." He was speaking of the "countless minor incidents" that make "everything in war (is) very simple, but the simplest thing is difficult."

CHAPTER 5: THE INFINITE AND THE INFINITESIMAL

Chapter 5 explores the motion of change with the analytical method introduced by Newton and Liebniz more than 300 years ago. With the complexity of a flat world compressed to a single theoretical point, the motion of order and disorder explores change in smaller and smaller intervals. Instead of breaking time into manageable straight-line periods to explore the chemistry of change, the Operational Calculus establishes patterns of change as nonlinear functions of time. Those functions are broken down and analyzed, then synthesized and put back together. The process is instant, and happens at every instant. The flipbook of change becomes the seamless motion of change through the comprehension of the infinite and the infinitesimal time.

A Changing Order

Given a set of historical change data to analyze, the natural tendency is to break the data up into periods of perceived greater or lesser change and categorize them along the lines of revolutions, pre-revolutions, or periods of relative stability. Crane Brinton, in *Anatomy of a Revolution,* categorizes four "revolutions in modern states" from the mid-seventeenth century to the mid-nineteenth century. Brinton analyzes these like periods for "certain first approximations of uniformities."[1] Brinton selected his historical eras as characteristic of rapid, significant change. Historian Bryon Greenwald looks at both periods of rapid change and the relative calm before the change in his dissertation, "Understanding Change: An Intellectual and Practical Study of Military Innovation." Greenwald suggests, "After a period of near stasis, a rapid change occurs in the conduct

[1] Crane Brinton, *Anatomy of a Revolution* (New York: Prentice Hall, Inc., 1952), 5.

of warfare that alters the way wars are fought. This change dominates warfare, albeit undergoing and giving way to incremental change, until supplanted by another rapidly emerging method of warfare."[2] History broken up into revolutionary periods in which the rate of change is somewhat constant allows for a more accurate estimation of the true nature of change; however, only history affords the luxury of selecting discrete time periods with similar rates of change. The military commander, or any observer for that matter, only realizes the revolutionary moment of change after the fact.

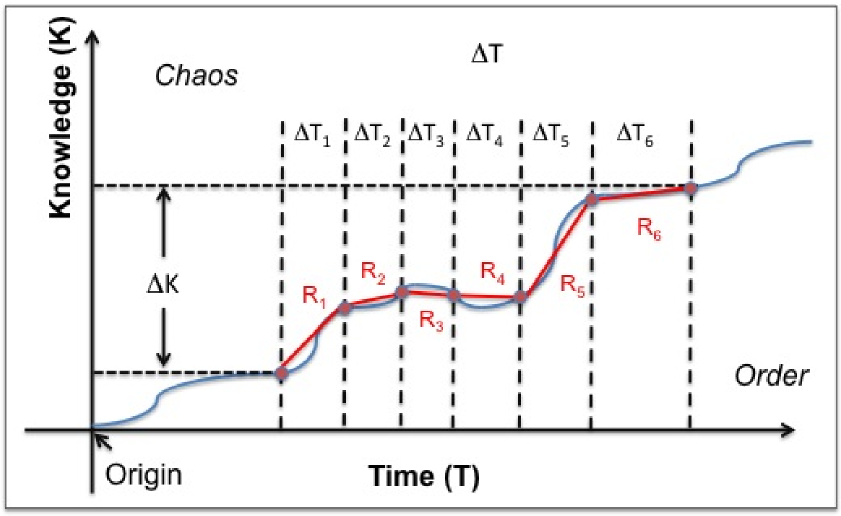

Figure 5-1: Periods of Change[3]

Figure 5-1 shows an aggregate change in knowledge broken up into discrete periods of time based upon a "like" rate of change. Some periods are relatively stable in terms of the state of order and chaos, while others are rapidly fluctuating. The rate of change in each period is shown as R. The period defined by R_6 appears relatively stable; however, this should not be confused with a lack of change. It is not stability, nor is it

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[2] Bryon Greenwald, "Understanding Change: An Intellectual and Practical Understanding of Military Innovation" (PhD diss., The Ohio State University, 2003), http://etd.ohiolink.edu/view.cgi?acc_num=osu1070502037, (accessed February 15, 2012), 63.

[3] Figure 5-1 marks the transition to the analytical phase of the cognitive build of order and chaos. Previous figures were used to represent complex information; further figures in the analytical phase will be used to evaluate information.

equilibrium. It is simply a less abrupt change in the collective state of order. Change is continuous, but over certain periods of time the exchange of order and chaos is more stable. There are still changes on-going within the web of complexity, but not altering (as much) the macro state of order and chaos.

Kim Jong Il, the leader of The People's Republic of North Korea since 1994, died in December of 2011. His death was not wholly unexpected, but came sooner than most predictions. As of this writing, his death has not proven to be a world-altering event--yet.[4] So far, it has been a relatively peaceful transition. History would perceive this period now, if viewing the collective state of order and disorder in North Korea, as relatively stable. However, the complexities of the environment have changed dramatically. One intuitively senses that there is a potential danger lurking; however, from a macro view the state of order and disorder has not changed. Below the surface, in that cognitive web of complex relationships, many things have changed. No matter how much he is like his father, Kim Jong Un will comprehend the world through a different cognitive lens. The line segments representing relationships between Kim Jong Un and his military leaders take different routes and intersect other cognitive segments in different ways. The collective perception of the people of North Korea views Jong Un differently than Jong Il. The environment has changed, so beware what appears to be the straight line of change.

From Figure 5-1, it is apparent that constant, linear change is artificial. Further, from the same figure, one will conclude that overlaying a straight line between two points connected by a curved path is not very accurate. Dividing the distance between the two

[4] Alan Cowell, "Kim's Death Inspires Worry and Anxiety," New York Times, December 19, 2011, http://www.nytimes.com/2011/12/20/world/asia/kim-jong-ils-death-inspires-anxiety.html?pagewanted=all (accessed February 15, 2012).

points into smaller distances increases the accuracy of estimation. Divide again, and the accuracy increases again. The pattern repeats and one realizes that dividing a curved path into the smallest possible line segments becomes a theoretical process of studying an infinite number of points. The most accurate estimation of the path of a curve is to get as near as possible to zero for the distance between points. As a function of time, the process of studying motion achieves the most accurate results if one is able to stitch together an infinite number of snapshots into motion. The solution, then, to understanding continuous motion of change, is to understand the behavior of a function as it is drawn closer and closer to an instantaneous moment in time.

Figure 5-2 shows the systematic decrease of the time interval of a nonlinear function. Each snapshot is halved from the previous perspective to produce a series of "zooms." The process could, theoretically, be repeated over and over until the time interval approached infinitesimally close to zero, but not equal to zero. The limit of the behavior of the function in this case, as Δt approaches zero, is a vertical line called a vertical asymptote, because the point chosen to focus on in Figure 5-2 is the inflection point.[5] The pattern of a line trending toward vertical becomes apparent without drawing an infinite number of time intervals. So, practical value is deduced to make sense of nonlinear behavior.

[5]Gellert, *Concise Encyclopedia of Mathematics,* 426. An inflection point is a locally extreme value at which the behavior of the function dramatically changes--one example is an inflection point as the "carrying capacity" of a system. At an inflection point the acceleration of a nonlinear path changes from positive to negative, meaning that the change, or the growth, is slowing. If a revolution could be accurately plotted in terms of order and disorder, the inflection point would be the instant in time where the capacity of the revolutionary movement could no longer sustain such change, due to any number of factors. An inflection point does not necessarily represent a causitive analysis of change, but rather a visual and mathematical representation of an important point in the state or rate of change. Acceleration will be studied further below.

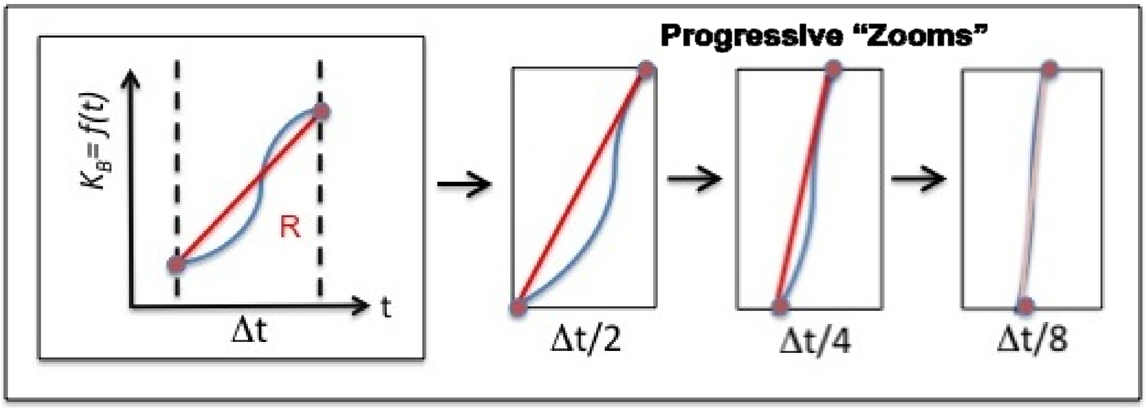

Figure 5-2: Instantaneous Velocity

Newton recognized the need to codify this system of intuitively recognizing patterns of infinitesimal change, and developed the method of the derivative calculus. In fact, "The invention of the differential calculus was based on the recognition that an instantaneous rate is the asymptotic limit of averages in which the time interval involved is systematically shrunk."[6] An asymptotic limit, briefly discussed in Part I, is a value that a function approaches, but never equals. Where functions of time are concerned, an instantaneous rate is the behavior of a function over decreasing time intervals with an asymptotic limit of zero. The question becomes one of describing the trend of a function over smaller and smaller intervals to estimate how it would behave at a theoretical instant. The only thing that matters is how the function is defined as it nears the original time value; in other words, as Δt approaches zero.[7]

In the Operational Calculus, as the average rate of change is analyzed for its behavior over smaller and smaller intervals, a pattern of mathematical relation emerges so that an instantaneous rate can be estimated. The instantaneous rate is the state of order and disorder at a theoretical singular position of the collective body of knowledge related

[6] Guillen, *Bridges to Infinity*, 27.

[7] James Stewart, *Single Variable Calculus, Fifth Edition* (Belmont, CA: Thomson Learning, 2003), 71.

to a single point in time. Since one cannot stop time, an instantaneous position retains a theoretical value only. Indeed, the body of knowledge has changed positions an infinite number of times during the time interval required to read this sentence. To study the real world, these instantaneous rates must be stitched together to understand the whole.

Derivative Operations

There is more than just theoretical value, however, in the instantaneous rate of change. The concept of an asymptotic limit applied to continuous functions like those based on temporal observation is the basis of the differential calculus. Consider the definition of the differential calculus in the context of what has been established thus far in the Operational Calculus:

> The objects of the differential calculus are functions, and its methods are the investigation and calculation of limiting values. Its central concept, the derivative of a function *f(x),* is a measure of the sensitivity with which *f(x)* reacts to a change in its argument. Because the relationships between quantities in the physical world can frequently be expressed by continuous and differentiable functions, only the differential calculus makes it possible in the natural sciences and technical disciplines to express mathematically not only states but also processes.[8]

Dynamic complexity bridged the chasm between physical objects and ideological concepts. Both operate on the border of a "phase transition" between a solid, ordered mass and a disparate, loosely connected set ideas or particles.[9] The study of the motion of the phase transition from order to chaos or vice versa, whether in the physical or metaphysical domain, requires the analytical method of derivative calculus.[10]

The mathematical definition of a derivative, $f'(x)$, is:

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[8] Geller, *Concise Encyclopedia of Mathematics*, 406.

[9] Waldrop, *Complexity,* 302.

[10] The term "metaphysical" is used synonymously with "ideological" to describe the realm of thought that determines physical action.

$$f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}.$$

This definition may seem intimidating, but the preceding section explained every portion of the mathematical notation used in the definition. Remember, $f(x)$ is simply a function--a pattern describing the relationship between two values. The change in the operational environment is a function of time; the state of order and disorder depends on when (and from where) you view it. The instant state of order and disorder is described as the position of the collective body of knowledge, K_B, so $K_B = f(t)$. The value h is introduced to describe the change in time between the first observation and the second observation of the body of knowledge, so $h = \Delta t$. Thus $f(t+h)$, or $f(t+\ \Delta t)$ describes the time at the second observed position of K_B. If the limit is ignored, the derivative formula is the same as any average value formula, including the average rate of change of the position of the body of knowledge.[11] But, the limit is what defines a derivative, and is exactly what was stepped through in the decreasing interval process above. To describe the behavior of the change of creation and destruction as the time interval is shrunk, then, the instantaneous rate of change is equal to the derivative of the average rate function:

$$f'(t) = \lim_{\Delta t \to 0} \frac{f(t+\Delta t) - f(t)}{\Delta t}.$$

Interestingly, the commandment "thou shall not divide by zero" is indispensible to the concept of a derivative, as in the physical world no one yet has figured out how to stop time. A time interval equal to zero, and thus a moment frozen in time, cannot exist--Δt can never equal zero. Mathematically and physically it doesn't work. But, Δt can get

[11] From Chapter 4, the average rate of change would be equal to: $\frac{K_{B2} - K_{B1}}{t_2 - t_1}$.

infinitesimally close to zero and the behavior of a function of time can likewise be described infinitesimally close to static. A derivative, $f'(t)$ is a function in its own right, and describes a pattern between values just as any other function does. The derivative of the position function describes the relational pattern between the rate of change, or velocity, and time. While there cannot be a zero change in the denominator, a derivative can in fact be found of a function that produces the same value at two distinct times, and thus a zero in the numerator.[12]

In other words, when the numerator is equal to zero, the state of order and disorder must be identical from one instant to the next, making K_{B2} equivalent to K_{B1}. The difference between the two, $K_{B2} - K_{B1}$, is equal to zero, in which case the derivative of the position function is equal to zero. If there is no change, there is no rate of change. The corresponding rule in calculus, with many applications, is that the derivative of a constant is equal to zero. Consider though, what it would mean to have zero change from one moment to the next. The whole lot of the variables (cognitive line segments) acting, reacting, and evolving at every instant would have to produce the same exact state of order and disorder through a process of creation and destruction. The odds against this are astounding, and for all intents and purposes, impossible without outside interference to stabilize an environment.

The lesson to teach the intuitive cognition from a zero-derivative is to look for straight lines--they do not happen naturally. If the rate of change were held constant in any environment, an investigation into the causes would likely uncover an artificial, and erroneous, perception. Nassim Taleb and Mark Blyth write about the dangers of

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[12] Stewart, *Single Variable Calculus*, 73.

artificially controlled complexity in their Foreign Affairs article, “The Black Swan of Cairo.” Taleb observes “complex systems that have artificially suppressed volatility tend to become extremely fragile, while at the same time exhibiting no visible risks. In fact, they tend to be too calm and exhibit minimal variability as silent risks accumulate.”[13] The naturally occurring variance in the state of order and disorder is suppressed, creating a perception of a straight line in the motion of change.[14] A static world only exists in books; the warning is repeated: beware straight lines.

A Constantly Accelerating Mechanism

One of the most cognitively troublesome problems facing those trying to comprehend today’s environment is the apparently chaotic pattern of change. Revolutions and riots, earthquakes and floods, and economic and political upheaval represent cycles of creation and destruction that bombard the consciousness. While these may seem like purely destructive mechanisms, with each state of order and disorder destroyed another takes its place. The physical, metaphysical, geographic and demographic landscape of Japan is permanently changed following the 2011 earthquake, just as the political landscape of North Africa is forever changed following the Arab Spring. The question is not whether there is a new order created; the question is whether the new state of order and disorder is more or less chaotic than the previous state. That question remains unanswered as the world struggles to develop its collective cognitive

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[13] Nassim Taleb and Mark Blyth, “The Black Swan of Cairo: How Suppressing Volatility Makes the World Less Predictable and More Dangerous” (Foreign Affairs, Volume 90, Number 3: May/June 2011), 33.

[14] Ibid., 33-35. Taleb and Blyth also draw the comparison to the economic collapse of 2008, and distinctly concludes that such events are not unpredictable, though common understanding of chaos and complexity would make them appear so. Black Swan events occur in artificially controlled complex environments where natural, evolutionary change is not permitted. Taleb says that to call them unpredictable is “naïve analysis” and that they were only unpredictable to a “given set of observers.”

framework to incorporate changed or newly discovered relational line segments into the whole of the complex environment.

Secretary of State Hillary Clinton noted the rapid pace of change in today's global landscape. In a television interview with the Public Broadcasting Station, Clinton concluded, "I've told a number of friends and colleagues that the intensity of the diplomatic enterprise is so much greater than it was even . . . back in the '90s. It's just a constantly accelerating mechanism that requires people to act often more quickly than the problem deserves. Yet that is the world in which we find ourselves."[15] Richard Danzig, in his essay "Driving in the Dark," put forth a similar conclusion: "The acceleration, proliferation, and diversification of technical and political change make the twenty-first century security risks even more unpredictable than those of the past."[16] Both Clinton and Danzig were speaking of high magnitude change over a short period of time. Some is orderly, some is chaotic, but the change is increasing in frequency.

The theme of accelerating change is prevalent throughout history, as observers have noted a non-constant rate of change. One such set of observations comes from Arthur Koestler, writing about the evolution of ideas in "The Act of Creation." Koestler categorized the seventeenth century as a "heroic age of science," contrasted to the eighteenth century in which "the speed of advance is considerably reduced."[17] Further, in the nineteenth century and first half of the twentieth century, "we have an explosive development of ever-increasing momentum. The nineteenth century was the age of the

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[15] Margaret Warner, "Obama's National Security Strategy, Brought to You by Secretary Clinton," http://www.pbs.org/newshour/rundown/2010/05/obamas-national-security-strategy.html, (accessed February 19, 2012).

[16] Danzig, "Driving in the Dark," 5.

[17] Koestler, *The Act of Creation*, 228.

most spectacular synthesis in the history of thought." These changes in thought occur at a non-constant rate "not gained by the steady advance of science along a straight line."[18] Koestler's book was published in 1964; one can only imagine how he would categorize the change of the past 20 years.

Clinton, Danzig, and Koestler introduce the concept of accelerating change. Acceleration is, in essence, a changing rate of change. As discussed above, if the collective state of order and disorder is constant then the instant velocity, or the derivative of the change function, is equal to zero. Acceleration, like motion, is path dependent--it has positive and negative values. An accelerating rate of change in a direction of further order and less chaos is positive; an accelerating rate of change in a direction of further chaos is negative. Secretary Clinton did not distinguish which direction she saw change taking, but she did point out the important aspect of the magnitude of acceleration. Regardless of whether the rate of change is accelerating in a positive or negative direction, when it has a large value in either the positive or negative direction, the change in order and disorder is happening ever more rapidly.

Acceleration is a relatively difficult concept to understand. Mathematically, acceleration is the derivative of the velocity function, or the second derivative of the position function, but still a function of time $f''(t)$.[19] The original pattern observed between the state of order and chaos over time was found to have average values for change, R that described the relationship between two instantaneous positions of the body

[18] Ibid., 226.

[19] R.C. Hibbeler, *Engineering Mechanics: Dynamics,* (New York: Macmillan Publishing, 1992), 5; the notation $f'(t)$ is notation to indicate that the function in question is a derivative function of $f(t)$.

of knowledge. As the average rate of change was analyzed over a shorter and shorter time span, an instantaneous rate was found.

The acceleration function, however, is not an entirely distinct concept independent of the order and chaos function. Instead of conceptualizing an entirely new function, the acceleration function is related to the original position function $f(t)$ by evaluating the behavior of the velocity function $f'(t)$ as the time interval is systematically decreased. When the analytical process is reversed, observations of the behavior of a derived function further determine criteria for predicting where change will lead. In other words, change, rate of change, and accelerating change are all related as functions of time.

The nature of change is changing, hence the adage "the only thing constant is change." It is only natural that the rate of change, particularly the rate of change of significant world events, is accelerating in a "flat world." There are more and more cognitive line segments thrown onto the same point in time every instant. Those segments intersect and converge to shape a new state of order and chaos faster than a linear cognition can order. Revolution in North Africa would have taken weeks or months to impact the cognitive state of a leader or the collective cognition of the populace in North America when Clausewitz wrote. Now, Libyans, Egyptians, Italians, Brits, and Americans see a man set himself on fire in Tunisia in real time. Even as recent as two decades ago cable news required an hour or two to report an earthquake in the Pacific, and as recent as a decade ago one had to pass by a television or radio to get word of the event quickly. But in 2011, the majority of the globe had news of the Japanese earthquake or the North African revolutions delivered to their hands instantly.[20]

As the world continues to flatten and places like North Korea or the Sudan join the global fray, they will bring with them another set of infinite data points to be ordered and added to the collective cognition. Change will continue to accelerate, both in a positive and negative direction. With accelerating change, the ambiguity and uncertainty of the strategic environment will build to an overwhelming condition if linear thinking is not abandoned. The "chemistry" of change simply has too many variables to understand without freezing time and isolating problems. The "physics of change," the nonlinear behavioral motion of order and chaos, analyzed with the operational calculus, is the only way to keep pace with understanding change.

Integrated Operations

The reverse process mentioned previously--how one puts individual pieces of observation back together--is historically more elusive to mastery than deductive analysis alone. Boyd saw that there was more to cognitive understanding than a derivative analysis. There had to also be a way to put the analysis back together to understand a nonlinear environment. Since nonlinear is, by definition, non-additive, the "putting back together" is more than simple addition. Boyd characterized the complement to derivative analysis as "synthesis," and, in fact, considered the term "analyst" a derogatory term. In his now-famous Conceptual Spiral presentation, he frequently opened with "One way you

[20] Jack Goldstone, "Understanding the Revolutions of 2011" (Foreign Affairs, Volume 90, Number 3: May/June 2011), 8.

can insult me is to call me an analyst. That's a half-wit. That's saying I have half a brain."[21] To Boyd, and to Newton, derivative analysis was only half of the picture.

The other half of cognitive understanding Boyd was talking about is the mathematical equivalent of integral calculus. Integral calculus deals with areas and distances, rather than position and rates. Specifically, integral calculus uses limits much like derivative calculus to understand nonlinear areas. With the nonlinear area problem, the reader again finds himself faced with the problem of estimating a nonlinear environment, but now with a different set of cognitive tools at his disposal. Integral calculus is introduced to the undergraduate mathematics student with the following description of the area problem:

> In trying to solve the area problem, we have to ask ourselves: What is the meaning of the word *area*? This question is easy to answer for regions with straight sides. However, it isn't so easy to find the area of a region with curved sides. We all have an intuitive idea of what the area of a region is. But part of the problem is to make this intuitive idea precise by giving an exact definition of area.[22]

The idea of an intuitive sense of the environment should perk the ears of military historians. It is a concept that has been prodded and dissected for centuries to try to discern why the skillful military commander has a precise sense of his nonlinear operating environment. Davis and Kahan, who assert there are two types of decision makers, analytical and intuitive, see intuition as an attribute distinct from analysis.[23] John Warden also sees the two as discrete approaches, but draws the distinction as

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[21] John Boyd, "Conceptual Spiral," http://homepage.mac.com/ace354/Boyd/iMovieTheater38.html, (accessed February 19, 2012). Link contains audio of Boyd's Conceptual Spiral Presentation.

[22] Stewart, *Single Variable Calculus*, 315.

[23] Davis and Kahan, *Theory and Methods for Supporting High Level Military Decisionmaking*, 11-19.

"inductive" and "deductive," and further proposes in his systems analysis "we must learn to think deductively."[24] Clausewitz recognized that "there is a gap between principles and actual events that cannot always be bridged by a succession of logical deductions."[25] The antithesis to deductive analysis, for Clausewitz, was the *coup d'oeil*, or the "inward eye" of the commander. The inward eye aided the intuitive perception of the whole environment. In the mind, "things are perceived, of course partly by the naked eye and partly by the mind, which fills the gaps with guesswork based on learning and experience."[26] The pattern of those gaps, so troublesome in Part I of the Operational Calculus, is systematically observed as the gaps are reduced. The pattern, in math, is the integral function; in application, the pattern is the intuitive perception or cognition of the commander.

The intuitive perception is not limited to military study. Malcolm Gladwell contrasts when to "blink" and when to "think" applied to a broad range of decision-making. Integration, in the terminology of Gladwell's decision-making lexicon, is the rapid cognition of the "adaptive unconscious."[27] Paul Saffo, in the Harvard Business Review, states that, "As a decision maker, you ultimately have to rely on your intuition and judgment. There's no getting around that in a world of uncertainty."[28] These authors are framing the cognition problem of understanding the area of a nonlinear environment,

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[24] John Warden, "The Enemy as a System," *Airpower Journal*, Vol.9, Issue 1 (1995): 1.

[25] Clausewitz, *On War,* 108.

[26] Ibid., 109. The "area problem" will be discussed in detail below.

[27] Gladwell, *Blink,* 15-20.

[28] Paul Saffo, "Six Rules for Effective Forecasting," *Harvard Business Review,* July-August (1997): 2.

and all seem to realize that using traditional Euclidean methods does not work. There remains too much uncertainty to make decisions of much value.

Boyd understood the application of the analytical methods of calculus as the alternative to linear thinking, identifying the mental calculus required to understand a complex environment:

> The differential calculus proceeds from the general to specific–from a function to its derivative. Hence is not the use or application of the differential calculus related to deduction and analysis? The integral calculus, on the other hand, proceeds in the opposite direction–from a derivative to a general function. Hence, is not the use or application of the integral calculus related to induction and synthesis?[29]

Synthesis is generally defined as "the composition or combination of parts or elements so as to form a whole."[30] The commander's cognitive integration, then, is the ability to synthesize the innumerable individual cognitive pictures he has accumulated through years of experience and the near infinite cognitive conclusions he has drawn through countless hours of study and thought on war. The "genius" commander intuitively assesses the environment with precision, accurately estimating the flow of the changing environment and deciding precisely where to apply his efforts. Sir Edward B. Hamley eloquently observed the commander's integration nearly a century and a half ago: "While distant spectators imagine a general to be intent only on striking or parrying a blow, he probably directs a hundred glances, a hundred anxious thoughts, to the communications in his rear, for one that he bestows on his adversary's front."[31] To

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[29] Boyd, "Destruction and Creation," 2.

[30] Webster's Online Dictionary: http://www.merriam-webster.com/dictionary/synthesis.

[31] Bruce Hamly, *The Operations of War Explained and Illustrated* (London: William Blackwood, 1878), http://books.google.com/books/about/The_operations_of_war.html?id=MbTzrcRjUf4C, (accessed February 19, 2012), 37.

explain the "art" of integrating hundreds of thoughts and observations in a single instant, such as Hamley described, one must once again turn his thoughts inward and explore the mathematical cognition of intuition.

The Area Problem (The Commander's *coup d'oeil)*

The method of approximating the area bound by a nonlinear function with decreasing polygons was previously discussed in this work, and the concept of limits established. If the area of one's environment were static, the area could eventually be estimated by summing an increasing number of symmetrical polygons. This seventeenth-century method to analyze areas bound by a nonlinear function was called the "method of exhaustion."[32] However, in a constantly changing environment, the area problem changes with each instant of time. An accurate and precise estimate of a fluid environment, analyzed with a linear methodology, requires time to again be stopped and the area understood at each frame in time before moving to the next.

Figure 5-3 returns to the nonlinear position function describing the position of the collective body of knowledge moving along the edge of order and chaos. Discrete time intervals are again chosen in a proportional division of time. Rectangles are drawn within each time interval, and the area of each rectangle is equivalent to the change in knowledge multiplied by the change in time,

$$A = (\Delta T_1) \text{ x } (\Delta K_1).$$

The total area under the curve from the beginning of the time interval to the end of the time interval is the sum of all of these discrete areas. It can readily be observed that the area of the polygons is not exactly equivalent to the total area under the curve. Some of

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[32] Gellert, *Concise Encyclopedia of Mathematics*, 444.

the rectangles exceed the area, while others underestimate the area. The process is repeated through a series of smaller and smaller rectangles until the estimate is precise.

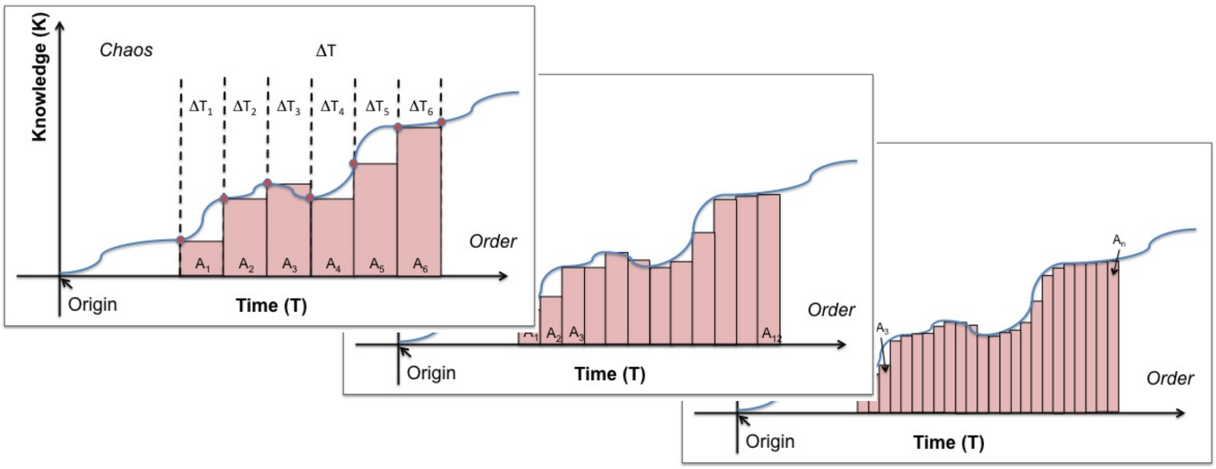

Figure 5-3: Thin Slices of the Environment

If A is used to represent the area under the curve, which in the position function represents the ordered environment, then:

$$A = \lim_{n\to\infty} \sum_{i=1}^{n}[(\Delta T_1)\text{x } (\Delta K_1) + (\Delta T_2)\text{ x } (\Delta K_2) + \ \dots + \ (\Delta T_n)\text{ x } (\Delta K_n)].$$

The area formula simply means what was explained above--that the more rectangles you draw the closer you get to understanding the true area. When all of the rectangles are synthesized into a whole, or integrated, over a finite area the formula becomes:

$$\text{A}=\int_0^t f(t)dt.$$

The mathematical notation is eloquently and precisely stating that the area is equal to the sum of an infinite number of rectangles bounded by the function that describes the motion of the point between order and chaos. Since again, there cannot be a time period of zero, the rectangles never become infinitesimally small, but do get smaller and smaller with no limit as to how small one could draw them. Before long, a pattern is observed which describes the height of the next rectangle, and the area is calculated precisely. Just as with derivatives, it is the behavior of the change that drives the intuitive calculation.[33]

The area problem is the quest to determine the collective area of order bounded by the curve representing the motion of the body of knowledge. As the spiral of line segments representing a collective state of understanding creates and destroys order over time, the area represents the cumulative progress, or lack thereof. A new aggregate area is established every instant. Koestler relates the integrated area to individual creativity: "The Eureka act proper, the moment of truth experienced by the creative individual, is parallel on the collective plane by the emergence, out of the scattered fragments, of a new synthesis."[34] Koestler's bridge should be a "Eureka act proper" for the reader. The creative imagination espoused in the doctrinal definition of operational art, the imagination of the planner, the ingenuity of the commander, and the "eureka act proper" are acts of intuitive synthesis. The "creative" distinction is in reality an educated and uninhibited mind quickly recognizing the pattern of the function of creation and destruction faster than a more inhibited or less capable mind.

Consider the pattern between two variables represented by the function $y=x^2$. The value of y at any point x is known as a function of x, and so the relationship can be expressed as $f(x)=x^2$. As a function of time, the relationship would be expressed as $f(t)=t^2$. To calculate the area under the curve after one second, the integral $\int_0^1 t^2$ must be solved. The formula implies that the area of $f(t)=t^2$ is equal to the function describing the pattern that emerges when the area is systematically divided into smaller and smaller

[33] Stewart, *Single Variable Calculus,* 315. Stewart presents the area problem with a similar methodology describing the path of a physical object.

[34] Koestler, *Act of Creation*, 225.

rectangles over the time interval zero to one second.[35] Since it is impossible to draw an infinite number of rectangles, the integral method looks for a pattern of behavior as the number of rectangles systematically increases.

Figure 5-4 shows the process of finding the area under the parabola curve using increasingly smaller polygons. Just like *a priori* man framing his environment, a series of line segments is drawn which touch the curve at symmetrical intervals. The process used is the "method of exhaustion" mentioned earlier--a method in which an unknown area is estimated using an infinite series of known areas.[36] The unknown area is over-estimated and under-estimated as close as possible with rectangles that intersect the curve at known points. The rectangles that over-estimate the area are "right endpoints" and the rectangles that underestimate the area are "left endpoints." As time is divided into systematically smaller intervals, the precision increases. The number of rectangles drawn is represented by "n," so that as n increases the precision also increases. When n=1 the area is known to be between zero and one since the entire curve is contained within the square with an area A=1. By the time n=4, the area is known to be bound by the interval: $0.2188 < A < 0.4688$. The area found by the method of exhaustion with four polygons (n=4) is more precise than using only one polygon, but still not very useful. It is only through the realization of the pattern of the rectangles (i.e. the function of the integral), that a precise understanding of the area can be known.

[35] Of note, the function $y=x^2$ is the well-known equation for a parabola and is often used to introduce the area problem to calculus students.

[36] Gellert, *Concise Encyclopedia of Mathematics*, 444.

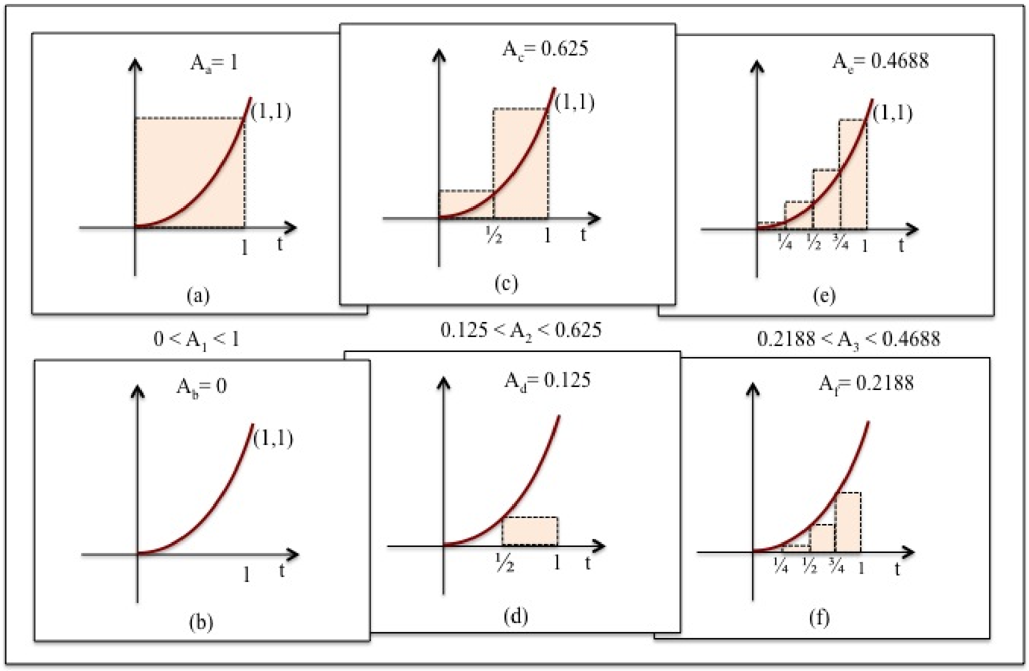

Figure 5-4: The Method of Exhaustion[37]

The explicit function describing universal order and disorder over time is not known, and the intent is not to imply that the whole state of the universe can be known quantitatively. The process of integration, though, is also not intended to be a metaphor for how one sees the physical world. It is a mathematical method developed to study motion and is just as applicable to cognition (i.e. the metaphysical) as it is to the physical world. Gladwell, in *Blink*, did not specifically cite the method of integration, but when he described "thin slices" of time he was using the integral method. He noted, "when we thin-slice, when we recognize patterns and make snap judgments, we do this process of editing unconsciously."[38] This is how humans intuitively think; it is when the intuitive process is misunderstood that integrations can go awry.

[37] Stewart, *The Single Variable Calculus,* 316-317. Figure 5-4 is based on the example used by Stewart but was re-created and modified by the author.

[38] Gladwell, *Blink,* 142.

The misinterpretation of Gladwell could lead one to believe that thin-slicing is a cognitive tool available to just about anyone. In a way, this is true. The brain does possess the ability to think in nonlinear ways, particularly in the "adaptive unconscious." But the process of putting the thin-slices back together requires wisdom, experience, and study in one's craft to hone the intuitive pattern recognition. Gladwell uses a series of stories about experts in a field who integrate an infinite number of thin slices to form an overall pattern that defies deductive analysis. The experts have *coup d'oeil*, but it is not based on creativity--it is based on the recognition of how a function behaves given a set of initial conditions. The intuitive integration is a cognitive process unconstrained by linear methodologies and not muted by the "inshallah" approach. In short, it is math, not art.

Leibniz and Newton realized that there had to be a better way of putting the rectangles back together than the exhaustive linear approach. There was clearly a pattern emerging with the "method of exhaustion." For continuous functions such as functions of time, Newton proved that the limit of the sum of the rectangles as *n* approached infinity existed and was equal to the area under the curve. Newton, Leibniz, and the mathematicians who followed went on to prove very useful rules for evaluating integrals, including the precise solution to the parabola problem.[39] The definite integral was shown to equal a distinct value when the function was evaluated over a defined interval. The indefinite integral, meaning no specific time interval is defined, was proven to equal a function expressing the relationship between two variables. As it turns out, the function of the indefinite integral is the key to unlocking a nonlinear cognition.

[39] The fundamental theorem of calculus allows the integral of $y=x^2$ to be found as $y=1/3x^3 + C$. Over the interval zero to one the area under the parabola would be 0.333. Using the method of exhaustion it would take nearly 1000 polygons to reach this level of precision.

The Fundamental Theorem of the Operational Calculus

The function of the indefinite integral is the facet of the Fundamental Theorem of Calculus that links derivatives to integrals and allowed for the study of Newtonian mechanics of motion with a systematic, nonlinear mathematical method.[40] The inverse relationship between the derivative and the integral is what Boyd referenced as analysis and synthesis, and why Warden was incorrect in his top-down approach. The fundamental theorem of the operational calculus says that to be accurate, a function must fulfill both the bottom-up realities and the top-down parameters. Operational art must integrate the realistic tactical environment within the restraints derived from the strategic environment. It is neither top-down nor bottom-up; it is both. Boyd said, in effect, that operational art is not for half-wits. Clausewitz and Napoleon said it takes a genius. "The man responsible for evaluating the whole must bring to his task the quality of intuition that perceives the truth at every point. Bonaparte rightly said in his connection that many of the decisions faced by the commander-in-chief resemble mathematical problems worthy of the gifts of a Newton or a Euler."[41]

Newton and Leibniz brought forth calculus out of the ether and left a method learned, and understood, by millions of people. Not all who understand calculus possess the innate *coup d'oeil* of Napoleon, Lee, or MacArthur, but in theory they could.[42]

> The Fundamental Theorem of Calculus is unquestionably the most important theorem in calculus and, indeed, it ranks as one of the great accomplishments of the human mind. Before it was discovered, from the

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[40] Carl Boyer and Uta Merzbach, *A History of Mathematics* (New York: Wiley, 1987), Chapter 19.

[41] Clausewitz, *On War,* 112.

[42] The author, as did Clausewitz and Laurence, recognizes that there is more to decision-making under stressful conditions than cognitive ability. Physical limits and general temperament play important roles as well. All of these factors come into play in the discussion of mass, force, momentum, and energy in Chapter 6.

> time of Eudoxus and Archimedes to the time of Galileo and Fermat, problems of finding areas, volumes, and the lengths of curves were so difficult that only a genius could meet the challenge. But now, armed with the systematic method that Newton and Liebniz fashioned out of the Fundamental Theorem, we will see . . . that these challenging problems are accessible to all of us.[43]

The military establishment would be well-served to stop ignoring the gifts left to the masses by the genius of Newton and Leibniz and embrace a new way of thinking; in fact, a new way of thinking that is 300 years old.

The Fundamental Theorem of Calculus states that differentiation and integration are inverse processes. If one integrates a function and then finds the derivative of the result, he ends up with the same function with which he started. The same holds true for the top down approach--if one finds the derivative of a function and then integrates the result, he ends up right back with the original function. This seemingly straightforward observation has changed the world in myriad ways, and the "development of many disciplines is unthinkable without it."[44]

It is important to note that a derivative of a function is still a function in its own right; the original function is$f(t)$, and the derivative function is $f'(t)$. The derivative method proven in this chapter produces a second pattern $f'(t)$ when applied to the original pattern $f(t)$ of something changing with time. The second pattern, $f'(t)$ describes something else changing with time, but still related to the first function. In the physical world, the derivative of the position function is the function of velocity, or rate of change. The indefinite integral of the velocity function is the position function, but the integral over a defined interval returns the value of the total distance traveled by the

[43] Stewart, *Single Variable Calculus*, 347.

[44] Gellert, *Concise Encyclopedia of Mathematics*, 406.

object.[45] This fundamental relationship between analysis and synthesis, or derivatives and integrals, creates an ordered whole from disparate conclusions as patterns emerge. The patterns are observed relationships stored as cognitive functions and applied as the intuitive calculus.

Summary

Many have seen, knowing or unknowingly, the cognitive method of calculus applied to both the physical and metaphysical universe. The motion of change is understood by evaluating time intervals approaching zero and integrating a number of "thin slices" approaching infinity. The infinitesimal implies that continuous change doesn't happen in two-second intervals or one-second intervals. It happens in infinitesimally small intervals. The infinite implies that complete certainty of a nonlinear area is not known through the study of four or eight historical periods. Certainty is only known by understanding the behavior of a pattern of an infinite number of periods. The world is not completely predictable, but it is changing, and change is a function of time. Functions have patterns, perhaps even aesthetically pleasing patterns, but once again they are not art.

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[45] Knight, *College Physics: A Strategic Approach*, 11.

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CHAPTER 6: NO MASS

So far, the concepts discussed focused on the behavioral functions of change more so than the causative agents of change. The pattern, or behavior of change, was analyzed using the derivative and integral calculus to understand change, rate of change, and accelerating change. The area beneath the change function was shown to be an integration of an infinite number of instances, and the area problem used to define phenomena related to change. It was at this point in his study of physical change in the universe, the point where the pattern of change required more definitive cause and effect analysis, that Newton developed his now-famous laws of physics describing the causes of motion. With a new mass defined in terms of change, the laws of physics apply equally to the metaphysical domain, proving a fundamental theorem lies in the cognitive realm of science, not the creative realm of art.

The Dynamics of Change--with Mass

Newton's laws of motion "explain" rather than "describe" change. In classical mechanics, describing change is kinematics; explaining change is dynamics. Max Jammer, in his book, *Concepts of Mass in Physics and Philosophy*, explains the kinematics and dynamics:

> Kinematics is the science that deals with the motions of bodies or particles without any regard to the causes of these motions. Studying the positions of bodies as a function of time, kinematics can be conceived as space-time geometry of motions, the fundamental notions of which are the concepts of length and time. By contrast, dynamics is the science that studies the motions of bodies as the result of causative interactions. As it is the task of dynamics to explain the motions described by kinematics, dynamics requires concepts additional to those used in kinematics, for 'to explain'

> goes beyond 'to describe.' The transition from kinematics to dynamics requires only one additional concept--the concept of mass.[1]

The term "dynamic complexity" has been used to describe a rapidly changing complex environment--complexity with accelerating change. In reality, the term applied should have been "kinematic complexity," as there has been no discussion of mass.[2] Semantics aside, to truly understand change one must explore the concept of "mass" further.

Mass is both an historical principle of war and a current principle of joint operations. The principle of mass made its first appearance as an explicit principle in J.F.C. Fuller's *Strategical Principles* in 1916 and debuted in Army doctrine in the 1949 version of Field Manual (FM) 100-5.[3] The descriptions and discussions of mass in war vary over the years, but most can be freely interchanged with the Jominian concept of concentration. Mass, from this perspective, is a point where forces (or effects) are concentrated.[4] Current US doctrine, ironically, has no definition of mass even though it

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[1] Max Jammer, *Concepts of Mass in Contemporary Physics and Philosophy* (Princeton: Princeton University Press, 1999), 5.

[2] Hibbeler, *Engineering Mechanics: Dynamics,* 1. In Mechanical Engineering, the field of dynamics is divided between kinematics, "which treats only the geometric aspects of motion," and kinetics, "which is the analysis of the forces causing the motion." Chapter 5 of this thesis described the kinematics of change while Chapter 6 will explore the full dynamics of change, inclusive of both kinematics and kinetics with the concept of mass.

[3] Alger, *The Quest for Victory*, 232-254.

[4] Ibid., 23-30. One of the earliest uses of the term mass comes from Jomini. Alger translates 10 principles published in a French pamphlet by Jomini in 1808, "L'art de la guerre." Principle 7 states: "It is not sufficient for success in war to skillfully bring masses to the most effective points; it is necessary to know how to employ them there. If a force arrives at a decisive point and is inactive, the principle is forgotten; the enemy can counter attack. Principle 8 states: "If the art of war consists of bringing the superior effort of a mass against the weak points of the enemy, it is undeniably necessary to pursue actively a beaten army." Principle 9 continues: "In order to make superior shock of a mass decisive, the general must give care to raise the morale of his army." Principle 10 concludes: "By this rapid review, it is seen that the science of war is composed of three general activities, which have only a few subdivisions and few opportunities of execution. The first is to hold the most favorable lines of operations. Second is the art of moving masses as rapidly as possible to the decisive point. Third is the art of simultaneously bringing the greatest mass to the most important point on the battlefield."

is a principle of war. The best doctrine has to offer on mass is in *Joint Publication 3-0, Joint Operations*, which states:

> The purpose of mass is to concentrate the effects of combat power at the most advantageous place and time to produce decisive results. In order to achieve mass, appropriate joint force capabilities are integrated and synchronized where they will have a decisive effect in a short period of time. Mass often must be sustained to have the desired effect. Massing effects of combat power, rather than concentrating forces, can enable even numerically inferior forces to produce decisive results and minimize human losses and waste of resources.[5]

The doctrinal discussion on mass is agonizing. The first sentence states that "The purpose of mass is to concentrate," and the second sentence goes on to essentially say that to achieve mass you have to concentrate. This circular, tautological definition brings the paradigm crisis full circle, back to the same cognitive state that prompted Clausewitz to pen his fundamental theory of the nature of war.[6] To untangle the complex cognitive web, the dynamics of war requires a concept of mass that applies across all levels and all domains, both in the physical and the metaphysical realms.

New Mass

Mass has been more explicitly defined in mechanics as "a quantitative measure of a body's resistance to being accelerated."[7] The term "quantitative" obviously precludes the direct transfer of this definition into military doctrine. Quantitative measurement of change only works in the physical realm, and is, at the moment, not feasible given the limited understanding of the numerous variables that comprise the bodies of social, military, or economic knowledge. This problem has festered since the end of the

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[5] Joint Staff, *Joint Operations,* A-2.

[6] Clausewitz, *On War,* 61. As noted in Part I, Clausewitz deplored the "trite wisdom" of his day and gave the example of lengthy firefighting doctrine to describe left and right sides of a house.

[7] Sybil Parker, ed., *Dictionary of Engineering* (New York: McGraw-Hill: 1994), 313.

nineteenth century, as “physicists and philosophers have been cherishing the hope that all of the problems related to mass could be resolved if a theory could be constructed that reveals what they called ‘the nature of mass,’ that is, a theory that explains the origin, existence, and phenomenological properties of mass."[8] Ernst Mach, too, wrote of the struggle to conceive a useful theory of mass in his historical account of mechanics, noting, “All uneasiness will vanish when we once have made clear to ourselves that in the concept of mass no theory whatever is contained but simply a fact of experience."[9] Such a hollistic theory of mass still does not exist.

The struggle with the concept of mass in the ideological domain also plagues those who study revolutionary change. Bryon Greenwald devotes a chapter in his dissertation to the “Internal and External Dynamics of Change.”[10] In Greenwald’s “dynamics of change,” there is no explicit mention of mass; however, the analogy is drawn comparing a large institution like the military to a high-mass object such as a oceanliner. Greenwald concludes, “The military, particularly in the United States, is a large bureaucratic organization and like a large ocean going vessel, it changes direction very slowly.”[11] Using the mechanical definition of “resistance to being accelerated,” a ship certainly exhibits a high degree of mass, as does the military establishment Only the

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[8] Jammer, *Concepts of Mass in Contemporary Physics and Philosophy*, 143.

[9] Ernst Mach, *The Science of Mechanics: A Critical and Historical Account of its Development,* Thomas MacCormick trans. (Chicago: The Open Court Publishing Company, 1919), 244. Available as ebook, http://www.archive.org/stream/scienceofmechani005860mbp#page/n5/mode/2up (accessed February 19, 2012). Mach’s full quote reads: "As soon as we, our attention being drawn to the fact of experience, have perceived in bodies the existence of a special property determinative of acceleration, our task with regard to it ends with the recognition and unequivocal designation of this fact. Beyond the recognition of this fact we shall not get, and every venture beyond it will only be productive of obscurity. All uneasiness will vanish when we once have made clear to ourselves that in the concept of mass no theory whatever is contained but simply a fact of experience."

[10] Greenwald, “Understanding Change: An Intellectual and Practical Study of Military Innovation,” Chapter 3.

[11] Ibid., 81.

most urgent and ominent of situations unites and accelerates the entire military establishment toward a common goal. There is not, however, a method to measure such a trait--resistance to acceleration--quantitatively, and thus the pursuit of a clear definition continues.

Thomas Greene approaches the mass question from a Jominian "concentration" perspective in *Comparative Revolutionary Movements.* Greene asks,

> But what do we mean by 'substantial numbers,' 'important percentages,' a 'large part'? How do we determine what constitutes the "critical mass" in the fusion and fission process of revolution? Even revolutions that succeed are based on a small percentage of the total population. If the revolutionaries have any advantage over the loyalists, it probably begins with the revolutionaries' greater commitment or intensity to their cause.[12]

Greene senses that the ideological mass causing revolutionary change does not equate specifically to numbers. Mass implies a resistance to change or a causative agent of change. Those with "intensity to their cause" possess an intrinsic resistance to changing their course and thus carry the revolutionary message further than those less intense. The study of the dynamics of change must consider the concept of mass as much in the metaphysical realm as it does in the physical realm.[13]

With the full realization that a quantitative relational measurement cannot be achieved, the concept of mass proposed in this study of dynamic complexity is "*the manifold characteristics of a body that resist change.*"[14] Mass is a characteristic of the

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[12] Greene, *Comparative Revolutionary Movements*, Annex-1.

[13] Green, *The Elegant Universe,* 12. Green talks about the concept of a quality resistant to change that exists in all systems, not just in gravitational force systems of physical bodies. "In electromagentic force systems, there exists a force charge that behaves just as mass does in a gravitational force system--it determines the system's resistance to change and how much influence a given electromagnetic force can exert on the system."

[14] Brendler, "The Stuff that Binds," 25. The mass definition is the work of the author, but was inspired by Joseph Brendler's definition of command: "I will use the word 'command' throughout much the same way as people commonly use the term 'management' to describe the manifold activities that go into

physical domain, as in a high mass body such as an ocean vessel. Mass is also resident in the ideological domain, as in the intensity of revolutionary ideas, or the ability of the military establishment to resist change. Physical mass can result in (or resist) ideological change, and ideological mass can result in (or resist) physical change. Both components of mass exist simultaneously and transfer between domains through individual and collective cognition. Mass is more than a "concentration;" mass is a characteristic of billions of years of complexity resulting in an instantaneous state of being with more or less capacity to resist change.[15]

Mass determines the magnitude of change effected. Both the physical and the metaphysical exist in "state-transition" or "phase transition" between creation and destruction.[16] The force of the change from one state of order to the next depends upon both the time period and the complexity of the change--the mass of the whole cognition of line segments, intersections, and areas. Mass, the traditional principle of the physical domain in war, or the characteristic of physical bodies in motion, can now transcend domains and have relevant meaning in modernity. The establishment of a concept of mass allows for the study of dynamic complexity from tactics through strategy through the fundamental theorem of Operational Calculus. This theorem, first conveyed to the

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the running of a business organization . . . it is not entirely rational and that it resides in the moral as well as the cybernetic domain."

[15] For an interesting military corollary, see Army Field Manual 100-5, Operations, 1982, 2-4. The 1982 version of FM 100-5 was the primary Air-Land Battle doctrinal manual and also notes the distinction between concentration and mass, though not explicitly: "Force ratios and the effects of fire and maneuver are significant in deciding battles; however, a number of intangible factors often predominate. Among these intangible factors are state of training, troop motivation, leader skill, firmness of purpose, and boldness." This text acknowledges that there is more than just troop numbers that determine force and power capacity, and more than just the speed with which the numbers of troops move.

[16] Chris Langan, "Cognitive Theoretical Model of the Universe," http://www.megafoundation.org/CTMU/Articles/Langan_CTMU_092902.pdf (accessed February 19, 2012). Langan writes about the historical duality of Cartesian mind/matter and considers the universe in a "state transition" of cognitive perception.

reader in the introduction of this thesis, will be discussed in detail in the next section of this chapter.

The Power of Force

The remainder of the discussion of dynamics will be, by necessity, brief. It was established that the introduction of mass into the study of change results in the investigation into the nature of change. Primarily, mass allows one to understand the application of force and momentum. Force is the product of mass and acceleration, or with the knowledge of calculus force is the product of mass and the second derivative of the position function. Unfortunately, doctrine doesn't shed any light on what exactly constitutes military "force," as there is no useful definition for "force" despite myriad uses.[17] There is possibly a general understanding of military force as the application of destructive power; however, power carries with it an entirely different connotation that further muddies the water.[18]

The general understanding of such a "destructive power" is the intuitive knowledge that military intervention by way of force brings with it an immediately altered state of order and disorder. This knowledge is representative of the fact that the application of force produces change in the position function--the function that describes the position of the state of order and chaos. The magnitude of the change in the state of order and disorder caused by a force is proportional to the amount of mass. Mass, again, is both qualitative and quantitative. A division of professional, well-trained, well-

[17] Joint Staff, *Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms* (Washington, DC, Department of Defense: 2011), 127. Joint Publication 1-02 defines force as "An aggregation of military personnel, weapon systems, equipment, and necessary support, or combination thereof." An "aggregation" does distinguish between force, mass, and concentration.

[18] Power will be discussed later in this chapter.

equipped, experienced soldiers is not equal in mass to a division of conscripted, untrained, under-equipped soldiers. But, conversely, even the most well-trained soldiers cannot defeat an infinite enemy. Further still, the intensity of interests, as Clausewitz states, "the will that moves and leads the whole mass of force," defies quantitative measurement.[19] Force, as is mass, is quantitative and qualitative, physical and metaphysical.

Force, then, is path dependent--direction matters. The qualitative description of the change created by a force depends on whether it produces order or disorder, and whether or not order or disorder is viewed as positive change. Since mass is not precisely defined, even in the physical realm, neither is force. "Unfortunately, there is no simple one-sentence definition of force," even in the finite physical domain.[20]

Dynamic complexity, in this work, described a cognitive state of order and disorder consisting of a near infinite number of cognitive line segments framing a nonlinear environment--a sort of complex collective cognition changing frequently. That complexity was set against the backdrop of time to describe change as motion--the kinematics of complexity. The dynamics of complexity requires an understanding of each of those line segments and their respective relational values. The nature of an environment is known with a level of certainty depending upon the number of cognitive line segments framing the environment; more segments reduce uncertainty. Further, the "intensity" of one's belief in a reality increases as the certainty of a given perception of

[19] Clausewitz, *On War,* 184.

[20] Knight, *College Physics,* 107.

grows.[21] Intensity is among the “manifold characteristics that resist change,” thus the force required to change a held reality depends upon the mass of the idea and the time interval in which the change is desired. Change over a time interval is motion, rapidly changing motion is acceleration, and force the product of mass and acceleration. Every cognitive line segment from the first step of *a priori* man to the dynamic complexity of collective cognition in a flat world is required to even remotely grasp the concepts of mass and force, and yet the true nature of both remains elusive.

The dictionary of engineering defines force as “that influence on a body which causes it to accelerate.”[22] It may come as a surprise to some that these terms are so ambiguous, even in the physical realm. The key is to establish a known position with relative confidence and then build an understanding of motion based upon the initial position and a close observation of change. From there, an intuitive understanding of mass will emerge shaped by cognitive measurements. Greene does just that with his study of revolutions. "We are well advised then, to begin our study of the causes of revolutionary movements with reference to those events that are apparently the most closely associated with the outbreak of revolution. These accelerators are the final, or immediate, causes of revolution."[23] Pick a point and analyze change in the context of forces driving change. The compelling force that changes the state of order and chaos in

[21] Certainty and Intensity are relative to how long a certain cognitive model is held. If more cognitive line segments are drawn in an orderly fashion within a limited area bound by a nonlinear function, the uncertainty within that area decreases with each line segment drawn. The longer a model is held, the more observations one perceives to fit that model and solidify the belief. The conclusion presented here is the personal conclusion of the author based upon observation of faith-based cultures and how their religious dogma is shaped. For related readings, see Richard Dawkins, *The God Delusion* (New York: First Mariner Books, 2008) and Sam Harris, *The End of Faith: Religion, Terror, and the Future of Reason* (New York: W.W. Norton & Company, 2005).

[22] Sybil Parker, ed., *Dictionary of Engineering*, 211.

[23] Greene, *Comparative Revolutionary Movements*, 105.

a revolutionary way is an intense belief in the cause applied over a short time interval. Force is the product of mass and acceleration.

The relationship between force and acceleration became one of Newton's ingenious laws of motion, stating that force is the product of mass and acceleration. In fact, the force and acceleration connection was the second law described by Newton.[24] His first law of motion was built on another important observation about change--the relationship between force and the motion (or velocity) of the position function, rather than the acceleration of the position. Recall that the speed a particle moves derived from the position function of the particle. With path dependency established (i.e., determining whether the particle is moving in a positive or negative direction) the first derivative of the position function describes velocity.[25] When a particle of mass has velocity, it also has momentum–the tendency to continue moving in a similar manner unless accelerated or decelerated. Unless something interferes with the motion of the particle, it will continue moving in a straight line. "The natural state of an object--its behavior free of external influences--is uniform motion with constant velocity."[26] Newton's first law captures the natural tendency of motion, as "a particle not subjected to external forces remains at rest or moves with constant speed in a straight line."[27] An object in motion stays in motion and an object at rest stays at rest, unless influenced by another object.

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[24] See Knight, *College Physics: A Strategic Approach.* Newtons Laws are (not the original wording of Newton) as follows: First law: A body remains in constant motion unless acted upon; Second law: The the acceleration of a body is proportional to the force and inversely proportional to the mass (F=ma); Third law: For every action, there is an equal and opposite reaction.

[25] R.C. Hibbeler, *Engineering Mechanics: Dynamics* (New York: Macmillan Publishing, 1992), 3.

[26] Knight, *College Physics: A Strategic Approach*, 107.

[27] Sybil Parker, ed., *Dictionary of Engineering*, 336.

The laborious explanation of the natural state of an object, widely recognized as the concept of momentum, was observed by Newton to be the product of mass and velocity. The concept of momentum may seem obvious, but the establishment of Newton's first law codified an intuitive understanding in physics: "This inability to perceive that a moving body tends to persist in its course was the psychological roadblock which prevented the emergence of a true science of physics from the fourth century BC to the seventeenth century AD. Yet every soldier who threw a spear *felt* that the thing had a momentum of its own--and so, of course, did the victim whom it hit."[28] Newton built on Aristotle's "inertia" to describe the behavior of change, whether static or dynamic, with a comprehensive law that most "felt" intuitively.[29]

The concept of mass is essential in understanding not just the creation of momentum, but of destroying momentum. Newton's first law says that a body will stay in motion unless otherwise accelerated; it will continue onward with momentum (a product of mass and velocity) unless there is a change in velocity. A change in velocity requires a change in acceleration; if there is no acceleration the velocity is constant. The ability of a body to resist being accelerated is its mass, regardless of if the acceleration is in a positive or negative direction. So, mass is not just the characteristic that allows an object, or a set of ideas, to resist positive change, it is also the characteristic that allows an object, or a set of ideas, to resist negative change.[30] Mass can increase momentum, but can also oppose momentum.

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[28] Koestler, *The Act of Creation*, 236.

[29] Sybil Parker, ed., *Dictionary of Engineering*, 336. Newton's first law is "also known as the first law of motion; Galileo's inertia."

[30] Hibbeler, *Engineering Mechanics: Dynamics*, 404-408.

The term "momentum" is liberally used to describe a wide array of situations, both in the physical and metaphysical environments. A political candidate can be seen as having "momentum." A product increasing in sales is picking up "momentum." An idea for change, such as a revolution, has an instantaneous state of motion with more or less "momentum." The term captures the instant cognitive understanding of a changing environment. If time were stopped and the body in motion isolated from all external interference, the state of motion tomorrow, or next year, would be the same as it is today. If a snapshot of the political arena were taken today and isolated from external political forces, the surging candidate's trajectory would take him to his positive end-state of election, while the waning candidate would continue his descent to defeat. In reality, the laws of metaphysics will once again obey the laws of physics, and the political environment will subject the politician to competing forces continuously shaping the trajectory of the "race."[31]

The fact that bodies don't move in isolation was captured with Newton's second and third laws. The second law describing the relationship between force and accelerating change in position was discussed above. The third law is the law of equal and opposite actions. The third law of motion says that "for every action, there is an equal and opposite reaction."[32] Newton's third law is what prompted Clausewitz to describe the circumstances of war as "Everything in war is very simple, but the simplest thing is difficult."[33] Forces do not act unopposed. The environment itself reacts to the

[31] A race is a competition to project a body over a distance to a set end-state. A political race, then, is the competition to project a person, representing a set of ideas, over a distance to an end-state. The analogy can clearly be seen between the position function discussed here-in, and a function describing the motion of the order and chaos of a political race.

[32] Knight, *College Physics: A Strategic Approach*, 126.

[33] Clausewitz, *On War,* 119.

action applied; actively by way of opposing force or passively by way of eroding the momentum of an object through friction.

Both active and passive reaction should be considered at this point. To reach a desired position, the current position is established, the desired position estimated, and force applied to move a body with mass toward the desired end-state. The force expected to resist the applied force depends on the magnitude of the force applied. Newton's law states that the forces are "equal and opposite." They act in pairs. It follows from Newton's second law that force is the product of mass and acceleration, and in kinematics it was established that acceleration is rapid change of relative magnitude. Therefore, if abrupt change is desired, a high degree of force is required. If a high degree of force is applied, it will be met with a high degree of resistance. Further, if rapid change is desired, the force required to effect that change depends upon the mass of the object or idea to be moved. Active, deliberate opposition will be met if the change desired impacts a firmly held set of ideas.

Passive resistance is more along the line of Clausewitz's friction. The collective resistance may not be turned with force to oppose the desired change directly, but the natural state of the resistance gradually reduces the momentum of the force of change through attrition. In war, "Countless minor incidents--the kind you can never really foresee--combine to lower the general level of performance so that one always falls short of the goal."[34] At any instant, the collective momentum of a system is the sum of the momentum of each individual mass body, and each of those mass bodies is constantly encountering resistance. An outsider's perspective of the system may give the

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[34] Clausewitz, *On War*, 119.

impression of a neat and orderly convergence of ideas in a common direction, when in reality the direction of the entire body is the result of an abundance of forces in opposition. Picking one or two of these to focus on as representative of the whole can lead to disarray when a massive a body intervenes with speed, creating widespread disruptive momentum.

Iraq 2003: Speed or Mass?

General Tommy Franks, recalling the strategic National Security Council debates about appropriate force for the invasion of Iraq, described then-Secretary of State Colin Powell's philosophy of "overwhelming force." Franks wrote of Powell, "He was from a generation of generals of who believed that overwhelming military force was found in troop strength--sheer numbers of soldiers and tanks on the ground."[35] Franks, by contrast, felt that force could be generated through speed of application. "By applying military mass simultaneously at key points, rather than trying to push a broad, slow, conventional advance, we throw the enemy off balance. We saw this in Afghanistan--fast, rapid maneuver. This creates momentum. Speed and momentum are the keys."[36] Newton would say that both are correct, as long as one truly understand the role of mass. Since force is equal to the product of mass and acceleration, it follows that if speed of application is accelerated, so is the resulting force. Conversely, greater mass with less speed can also generate the same force. Franks' logic flaw was not with pure force generation; it was with the kinematics of the change required and a failure to realize the path dependency of force.

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[35] Tommy Franks, *American Soldier* (New York: Harper Collins: 2004), 394.

[36] Ibid., 396.

Franks was adhering to a strategy of “Shock and Awe,” a strategy that relied on rapid, decisive force intent on physically and psychologically debilitating the population.[37] In doing so, what Franks generated was both literally and figuratively a “shock”--a “motion of force lasting thousandths to tenths of a second.”[38] The “shock” campaign created a destructive force impulse that rippled through the fabric of the Iraqi population and stored in their psyche. The shock achieved its immediate objective with the destruction of the Iraqi military, but the blast shattered the collective momentum of the Iraqi society into thousands of disparate force elements acting in opposition. The “awe” portion of the strategy led Franks and others to believe that a crippled populace would instinctively comply with the change demanded by US interests.[39] Physics (and metaphysics) does not work that way. Every force is met with an equal and opposite reaction. Push hard into the psyche of a people and they will push back with whatever force they are capable of generating, proportional to the mass they possess.

The immediate accelerated movement of the “shock” approach generated force, but when the acceleration was removed, the momentum diminished rapidly. Newton’s first law says that momentum is a product of mass and velocity. The positive momentum directing change toward the US-desired end-state quickly diminished since the original force applied was more reliant on rapid application than a substantial mass element. Using Powell’s approach consisting of a high mass force, the required momentum to drive towards a desirable end-state would have demanded less velocity. A high mass

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[37] See Ullman, “Shock and Awe,” XI.

[38] Sybil Parker, ed., *Dictionary of Engineering*, 450.

[39] Bob Woodward, *Plan of Attack* (New York: Simon & Schuster, 2004), 22. “Powell thought that Wolfowitz was talking as if 25 million Iraqis would rush to the side of a US-supported opposition. In his opinion, it was one of the most absurd, strategically unsound proposals he had ever heard.”

Powell approach also would generated a high magnitude force with less acceleration, thereby eliminating the disruptive shock that dispersed Iraqi elements into chaos.[40]

The Iraq example ties the physical to the ideological using proven laws of the universe. This approach is not entirely novel, as authors have, for centuries, awkwardly applied Newton through a lens of distorted understanding. The Clausewitzian concepts discussed may have originally been based in a fundamental calculus similar to what has been discussed here, or it may have been the misapplied physical metaphor of which Brendler warns.[41] Today's doctrine certainly falls into the latter category, as does the level of understanding of many of those who conduct warfare. At best, practitioners of the military "art" display a basic mechanical understanding of change, but perhaps lack the time required for a thoughtful awareness of change from the tactical to the strategic level.

Finding the Energy to Make Order

With Newton's laws of physical change firmly established as postulates for universal behavior, whether physical or metaphysical, the dynamic complexity of the tactical to strategic environments can now be examined beyond the scope of kinematics established in Chapter 5. The concept of mass allows the position function describing the state of order and disorder to be rewritten as the instantaneous sum of a near infinite number of forces acting upon the body of knowledge. The state of order and chaos is a function of forces in action and reaction--the dynamic complexity of change, rather than the geometric space-time description of kinematics described in Chapter 5. The force

[40] See also Ullman, "Shock and Awe," X-XIV.

[41] Brendler, "Physical Metaphor," 33-36.

function considers the competition between different perspectives of the same reality. Those holding a perception of reality hold it with varying degrees of intensity, and wish to change the collective perception over varying time intervals. Some passionately desire dramatic, instant change and are willing to take extreme measures, even death, to propagate their perception. Others hold their ideas less firmly or perhaps are willing to be patient in accelerating change. The collective result is a set of forces projecting the state of order and disorder in a direction with a momentum at every instant.[42]

The kinematics of Chapter 5 did not evaluate why change was occurring--it simply pieced together observations about the behavior of change to look for patterns over time. The fact that a pattern exists supports the proposition put forth in Complexity Theory that there are a limited number of outcomes to a complex system.[43] If the potential outcomes were infinite, a pattern would not emerge. The study of the dynamics of change inclusive of the knowledge of mass and force helps narrow the potential outcomes even further. If one can determine through observation that an environment is moving rapidly in a negative direction, the next state of the environment is not unpredictable. To the contrary, it will continue to move in a similar manner unless a force acts in opposition. Since no force acts in isolation, a force is certain to act in opposition.

[42] Davis, *Theory and Methods for Supporting High-Level Military Decisionmaking,* 34. Davis and Kahan describe a "foresight approach" to understanding change. "The foresight approach characteristically seeks the potential drivers of change relative to a simple extrapolation." They continue with, "The drivers of change are rarely fully controllable. The changes to be understood may be almost continuous, each so small as to be barely perceived, or they may be discrete events. They may be natural, purposeful, or by-products of other purposes."

[43] Waldrop, *Complexity,* 102-130. Stuart Kaufman, a scientist at the Santa Fe institute, is considered the first to develop an algorithm to show the self-limiting patterns of complexity.

Figure 6-1 shows the interaction of forces as a function of time. Through the continuous process of cognitive derivation and integration, the collective body of strategy-makers is left with an understanding of the interplay of forces in the strategic environment over time; they have an intuitive knowledge of the position, direction, and momentum of the state of order and disorder. At the point represented as "now," the assumed trajectory of the state of order and disorder is shown by the red line. This assumed trajectory is based upon the observed historical slope of the path from the beginning of observation until now. From Chapter 5, it is known that the closer the linear approximation is drawn to a zero time interval, the more accurately one knows the true instant velocity of the motion. Conversely, it is only through the integration of an infinite number of these instant line segments over a broad enough historical timeframe that a precise estimation of the function can be established.[44] The strategic calculus demands both.

[44] Saffo, "Six Rules for Effective Forecasting," 7. Saffo's Rule#5 for effective forecasting is to "Look back twice as far as you look forward." Saffo's rule is mathematically based--over time the magnitude of the abrupt peaks and valleys of the motion of order and chaos balance out, so that a linear approximation will be closer to the actual trajectory of the environment.

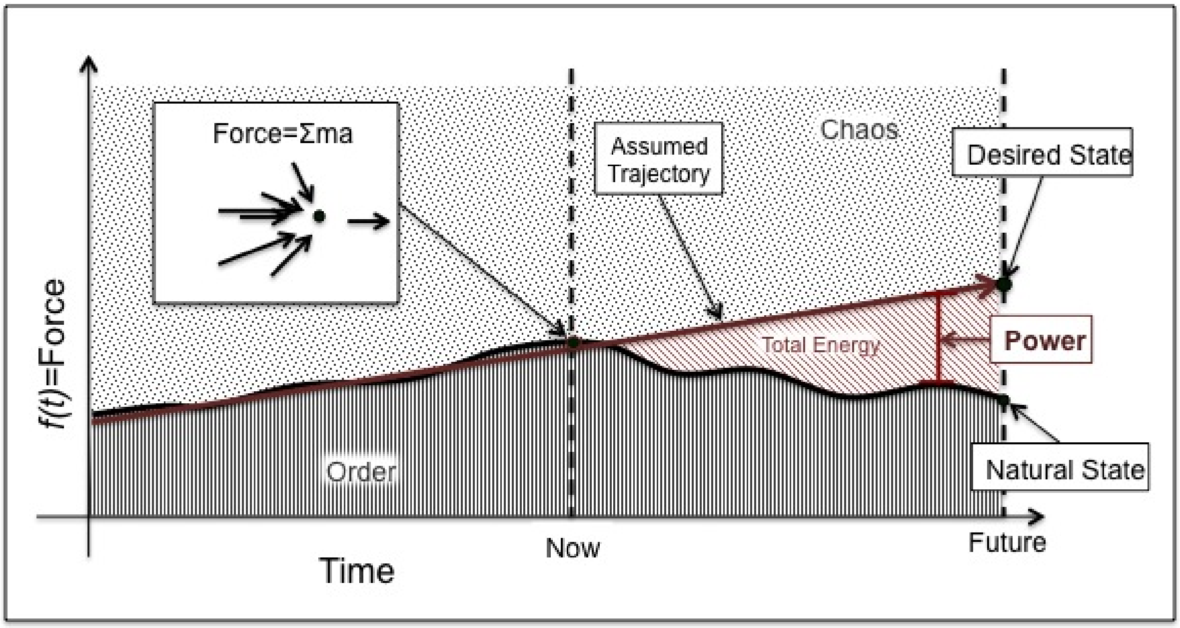

Figure 6-1: The Strategic Calculus

Reality may, and often does, take a different trajectory than the assumed or desired trajectory. The black line moving toward a lesser state of order and greater disorder shows the natural tendency of the environment without deliberate interference to change its course. In this instance, the environment can represent a state of order and chaos within a given geographic or functional domain. The environment could represent, for example, the state of affairs in Syria, Egypt, or Libya. The US has a desired state of order and an acceptable level of deemed disorder beneficial to its interests in those environments--perhaps to protect strategic access or to defend universal human rights while accepting a level of lawlessness or corruption. Whatever the interests are, the desired state of order and disorder is greater than the natural tendency over a given time period without US interference. The strategic calculus derives an instantaneous evaluation of the distance between the desired and current state, estimates the trajectory of both functions, and determines when interference is necessary based upon a set of established values or a threshold tolerance for disorder.

The strategic calculus, then, continuous through time and evaluates a difference in functions: the desired path toward greater order and the perceived trajectory toward lesser order. The area between the two paths is the work energy required to reconcile the trajectories.[45] Since the area under a nonlinear path is found using the integral method, the area of the energy function is the difference between the integral of the desired trajectory and the integral of the natural force function.[46] There is no discussion of energy in doctrine; however, in mechanics, energy is equivalent to work. Work is defined as "The physical or mental effort expended in the performance of a task."[47] By extension, the strategic energy is the effort expended in achieving the desired strategic end-state. The energy expended by the US in pursuit of its strategic end-states in Iraq is the total outlay of military, diplomatic, informational, and economic assets over the course of the entire conflict. To fill the gap between the real and desired endstates, even marginally, required near-perfect knowledge of both paths and precise application of energy. Neither was present. The US and its partners wasted much energy in the form of military, economic, diplomatic, or informational resources with flawed estimation and inadequate application.[48]

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[45] Hibbeler, *Engineering Mechanics: Dynamics*, 137-140.

[46] Stewart, *Single Variable Calculus,* 374-410. Chapter 6 of the *Single Variable Calculus* talks about applications of integrals, including the area between curves. In reality, the application of US force would cause a nonlinear motion of the state of order and chaos, resulting in an energy function described by the area between curves, not the area between a straight line and a curve as depicted above.

[47] Sybil Parker, ed., *Dictionary of Engineering*, 559.

[48] Joint Staff, *Joint Publication 1, x.* Diplomatic, Information, Military, and Economic (DIME) assets are considered the elements of national power by Joint Publication 1.

The relationship between strategic energy and the elements of national power is not coincidental; in physics, power is the amount of work performed per unit time.[49] Power in Figure 6-1 is shown as the vertical, bold red line demonstrating the direction and magnitude of power required to move the interaction of forces to the desired trajectory. Power in physics is path dependent. If energy is input into a system and propulsion does not occur in the direction desired, the energy is simply wasted. The same should hold true in estimations of national power outlay. Applying military might to an environment is not power if it does not alter the course of events in a desirable way, it is simply wasted national energy. True power is the ability to change the course of events in a positive direction. The magnitude of the power outlay depends on how quickly the desired change is affected.

Several conclusions can be drawn from the analysis of Figure 6-1. First, "smart power" judiciously chooses a desired state of order and disorder as close as possible to the natural state to minimize the outlay of "energy."[50] The desired state of order and disorder may not be a mature, Western-style democracy. It may be simply be an environment secure from massive disruptive force and free from disproportionate individual interests. Second, a good strategy is neither one of positive ends or one of

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[49] Hibbeler, *Engineering Mechanics: Dynamics*, 156. Power is the scalar time derivative of the energy function. The energy function is the observed pattern of the motion resulting from the simultaneous interaction of myriad forces.

[50] Hillary Clinton, "Leading through Civilian Power: Redefining American Diplomacy and Development," *Foreign Affairs,* November/December (2010). Clinton discusses "smart power" as the integrated approach of diplomacy, development, and military power, with a leading role for diplomacy and development. The non-military elements of power would encourage positive outcomes and redirect organic forces toward more favorable end-states through long term growth and democratic governance.

See also Joseph Nye, *Soft Power: The Means to Success in World Politics* (New York: Public Affairs, 2004), 1-8. Nye talks about power as "the ability to get things one wants." Soft power is the "ability to shape the preferences of others" whereas "hard power" is the traditional "carrot" and "stick" approach. "Smart power" combines both hard and soft power to affect a positive change in the environment.

punitive action--it is both. The position of order and disorder is not a system at equilibrium. If it were, there would be zero change over time. The position is the sum effect of numerous forces acting and reacting in an environment. Some of these forces desire to move the state of order and disorder irreversibly toward chaos; those forces need to be countered with adequate mass and acceleration, normally in the form of military force. Other forces may be encouraged toward a more desirable state of order with a keen application of power in the right direction, perhaps with informational assets or economic incentive. A "smart" outlay of power capitalizes on momentum, violently counters seemingly irreversible negative forces, and promotes positive forces, all toward a judicious end-state.

The Fundamental Theorem, with Mass

The Fundamental Theorem of the Operational Calculus pulls together the derivative method and the integral method with the understanding of mass. The fundamental theorem is the theoretical underpinning of dynamic complexity from a single thought to the strategic outlay of power shown in Figure 6-1. The Fundamental Theorem of the Operational Calculus states:

> *Operational art is the intuitive process of deriving direction and tempo from the position and parameters established at the strategic level to apply force and project power through the employment of integrated tactical functions.*[51]

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[51] Stewart, *Single Variable Calculus,* 340-347. The Fundamental Theorem of Calculus is "unquestionably the most important theorem in calculus and, indeed, ranks as one of the great accomplishments of the human mind." The fundamental theorem "establishes a connection between the two branches of calculus: differential calculus and integral calculus." The two branches were methods developed to deal with seemingly unrelated problems--the area problem and the tangent problem. The fundamental theorem says that the two are inverse processes: if the derivative of a function is found, the integration of that derivative results in the original function. Similarly, the Fundamental Theorem of the Operational Calculus states that the process of deriving from the strategic level and integrating from the tactical level are related by the operational function. To satisfy both tactical and strategic requirements, the operational function is simultaneously a derivative of the strategic function and an integral of the tactical function.

Figure 6-2 shows the definition of the operational calculus with the process of integration and derivation written in language presented in this thesis. The intuitive process, or the *coup d'oeil* of the commander, is the integral and derivative methods used to understand the operational environment as a function of time. Direction is the path-dependency discussed: what state of order and chaos does strategy drive towards? Tempo follows closely: how quickly must the change be accomplished? The position and parameters are the current estimation of the state of order and disorder in the world, and the acceptable disruption to be caused in the pursuit of a more favorable state of order and disorder.

At the operational level, the strategic power outlay must be translated into how military force is applied at the tactical level to achieve a desirable strategic end-state. Tactics to destroy opposing forces, as well as tactics to enhance supporting forces, must be fully integrated at the operational level over smaller and smaller periods of time. Their success is the area problem: how well is the power of the military apparatus enabling the outlay of strategic US energy to move the state of order and chaos toward a more desirable position? Operational art and operational calculus are synonymous in this context. The fundamental theorem says that the doctrinal thought process considered "art" is really a cognitive, intuitive calculus performed every instant.

Operational Art is the intuitive process of deriving direction and tempo from the position and parameters established at the strategic level to apply force and project power through the employment of integrated tactical functions.

If Strategy is the function of time, $f(t)$, and tactics a function of time $f''(t)$, then:

A: Operations = $f'(t) = \lim_{\Delta t \to 0} \frac{f(t+\Delta t)-f(t)}{\Delta t}$ and

B: Operations = $\int_0^t f''(t)dt = \lim_{n \to \infty} \sum_{i=1}^{n} f''(t_i)\Delta t$

Operational Art

Operational Calculus

Figure 6-2: The Fundamental Theorem of the Operational Calculus

The application of Newton's calculus in the physical world led to discussions of energy, power, work, and eventually a state of order and disorder called "entropy."[52] The debates continue today through propositions of grand, all-inclusive theories of the universe such as "M-Theory" and "Superstring Theory."[53] There simply are not concrete answers just yet to the world's biggest questions. However, if the same way of thinking is applied to the military discipline, it will become apparent that from grand strategy to individual tactics, the universe of war is connected. It is connected by physical and metaphysical energy, power, work, force, and most importantly, by mass.

War is not understood by "the creative imagination" of the commander; the operational calculus of the commander connects the universe of war. The cognitive methods applied at the operational level are derived from the strategic level, but must be

[52] Knight, *College Physics: A Strategic Approach,* 358. Entropy measures the amount of disorder in a system.

[53] See Hawking, *The Grand Design,* for a discussion of M-theory; See Green, *The Elegant Universe,*for a discussion of Superstring Theory.

a possible solution of integrated tactics. Top-down is not the answer, nor is bottom-up. Solutions at the operational level must be fundamentally responsive to strategic guidance and also fundamentally informed by realities at the lowest level. Commanders and their staffs cannot be "half-wits;" they must derive and integrate as continuous functions of time. The fundamental theorem implies exactly what Boyd observed, "If we cannot reverse directions, the ideas and interactions do not go together in this way without contradiction."[54] If, instead of understanding, the operational commander is left with contradiction he does not have art, he has a paradigm crisis.

Summary

In contrast to the deeply rooted concepts in the fundamental theorem above, today's doctrinal paradigm of joint operational art relies improperly on the commanders "creative imagination" to pull it all together. Creativity can lead to chaos if it is not a function that recognizes how to turn national energy into effective military power and project that power through an integrated tactical force. The smart use of power must alter the course of events in a desirable way with full consideration given to the laws of physics and metaphysics. Conversely, there is no law of creativity that says art must fulfill certain objectives; the aim of art is to express, not to explain. War is not chaotic, it is complex. The next state of the environment is not wholly unpredictable, it follows logical rules limiting the possibilities of "what happens next." Contrary to the assertions of Clausewitz and Jomini, these rules, and this chapter, prove once and for all that war is a science, not an art.

[54] Boyd, "Destruction and Creation," 3.

CONCLUSION

There are varying perspectives of how the ideas of Clausewitz came to be the theoretical foundation of modern operational art, but objective observation and experience indicate that our doctrinal operational art is indeed based upon a Clausewitzian underpinning. Perhaps the doctrinal impact was not the trajectory Paret & Howard had in mind when they reintroduced *On War* to a humbled military establishment in 1976, but the trajectory of the universe can, and often does, take an unforeseen course. It was certainly not the intent of the authors of joint doctrine to introduce a panacea with the 2006 definition of operational art. They were simply trying to make a cognitive quilt out of the patchwork of ideas they were given. But, as Thomas Kuhn noted, in paradigm crises, "An apparently arbitrary element, compounded of personal and historical accident, is always a formative ingredient of the beliefs espoused by a given scientific community at any given time."[1] The crisis in cognition is real, and it threatens the collective cognitive foundation of the community of military thinkers. Those that adapt to a new way of thinking, survive. Indeed, change and exchange determine the continued existence of a body.

Further, change is change, whether describing physical beings or metaphysical ideas. The operational environment is continuously changing in a fluid motion of dynamic complexity. The complexity does not become ordered with a "can do" attitude alone. The "can do" attitude can draw as many linear segments as a lifetime will allow and still not have a sensible system of cognition. The behavior of change is one of creation and destruction, with new realities constantly created and destroyed. The

[1] Kuhn, *The Structure of Scientific Revolutions*, 4.

military must move past Euclidean methods and past the Trinity put forth in the recognition that Euclidean geometry did not work. It must move to a theory of continuous change in which untold forces are interacting at each instant.

In the words of Colonel Boyd, “Don’t be a half wit.” The fundamental theorem says that derivative analysis from strategic guidance is not sufficient, nor is the isolated integration of tactical functions. Top-down is not the solution, nor is bottom-up. To be successful at the operational level, those charged with solving complex problems must think deductively and intuitively simultaneously. They must recognize the patterns of change and predict with greater certainty the next state of order and chaos in the pattern, for it is only through the consideration of a plethora of perspectives that certainty, or something approaching uncertainty, can be achieved.

The lessons waiting to be learned from a nonlinear thought process are many: beware of straight lines because only artificial change is linear; the *coup d’oeil* of the commander is not mystical, it is a manifestation of the intuitive “area” problem; and chaos is not complexity, and complexity is not unpredictable--it just requires critical thinking, not impossible thinking. Mass and concentration are not synonymous, and neither are force and power, but all are connected as a function of time. Destruction is not power unless chaos is the goal; true power is the ability to alter the course of events in a desirable way. These are all conclusions available to the military thinker with the infinite and the infinitesimal in his cognitive arsenal, but not to the operational artist who chooses faith in creative imagination.

The current concept of operational art simply has to change. It will lead down a path of further confusion and contradiction, toward chaos instead of order in the application of military doctrine. The physical metaphors introduced through generations of collective military writings are useful, and should be kept in the military lexicon, but only with a thorough understanding of the math behind the mechanics. Mass must be understood as a resistance to change--a resistance to movement of an object and resistance to movement of ideas. Without a new mass recognized through a new way of thinking, the negative trajectory of operational art will continue toward chaos unless a force intervenes to change the momentum in a positive direction. Perhaps, if enough mass is garnered, Operational Calculus will be the force to counter the the chaotic descent of operational art. After all, from the time of Newton up through today, every action has been paired with an equal and opposite reaction, even in the realm of ideas.

APPENDIX A: MORE THAN ACADEMIC

The Operational Calculus is limited in depth of exploration, and is intended to focus on introducing a mathematical way of thinking to aid in critical thinking. The application of this analytical method, sadly, must be left in many ways to the reader. There are entire fields of study dedicated to the applications of nonlinear mathematics to all facets of life, including the social sciences, economics, and certainly in the physical interaction of objects. Many could have been chosen for this work, including a study of exponential growth–the troublesome "S" curves of rapid growth and decay. Population functions and the relevance of mathematical concepts like inflection point and local extremes in social structures are also a field of study relevant to military operations. For the purpose of informing a military reader, two applications of the Operational Calculus are presented below: a derivative analysis of tactical rules of engagement and an integral analysis of center of gravity.

Avoiding the Jerk: Applied Derivatives

It was shown that the derivative of the position function is the velocity function, and the derivative of the velocity function is the acceleration function. In some complex functions, the derivative of acceleration does not equal zero, meaning that if there is abrupt change in the state of order and disorder, the value of its third derivative has a slope.[1] While this may seem purely academic, the derivative of acceleration has significant application in the real world. If the value of the derivative of acceleration is outside of a very narrow band of acceptable limits, the function at this value implies

[1] See J.C. Sprott, "Some Simple Chaotic Jerk Functions, Madison, Wisconsin," University of Wisconsin, 1997 (American Journal of Physics, Vol. 65, No. 6, June 1997.

radical change in the physical environment. The motion associated with such a change can be seen as an abrupt departure from the status quo. In mechanics, this concept is called a "jerk."[2]

A mechanical jerk codifies the intuitive understanding of the "strategic corporal." In general understanding, the strategic corporal is a relatively low ranking element of a greater collective body whose actions impact the entire system in dramatic and disproportionate fashion. A corporal performing his duties as assigned likely does not cause tremors in the national security establishment. However, a corporal acting drastically outside of the parameters of acceptable behavior can indeed send shockwaves through the entire system, especially in a flat world. The tactical corporal becomes a strategic corporal when his actions transfer energy from the physical domain to the ideological domain, and that energy is then intense enough to travel rapidly upward through expanding environments until it has a global impact. The physical "shock waves" of a corporal's actions are limited to the immediate area surrounding his tactical action. When the actions dramatically disrupt the accepted collective cognitive domain, the shock waves travel rapidly in all directions far from the point of origin.

In applied physical applications, such as engineering, strict parameters are established to monitor a system in the event of a jerk and often control mechanisms are designed to correct or mitigate an abrupt change in acceleration automatically. Jerks can be catastrophic to mechanical systems. In warfare, it is no different, except perhaps for the automated response. If a soldier steps dramatically outside of the rules of engagement, his actions likely have immediate and far-reaching consequences,

[2] Parker, ed., Dictionary of Engineering, 278. Jerk is defined as the rate of change of acceleration. It is the third derivative of position with respect to time.

particularly in the ideological domain. However, as has been established, the two domains are not isolated. Hence, dramatic disruptive energy caused by physical action, if left unmitigated, rapidly shoots through the collective cognition and creates a much-altered state of order and disorder.

Several examples come to mind of relatively low ranking individuals acting well outside the norms of behavior and causing disruption and chaos at the strategic level. The 2004 Abu Ghraib detainee abuse scandal in Iraq certainly shocked the international psyche. Paul Bartone, from the Center for Technology and National Security Policy, assessed the event as having "far-reaching consequences, leading many people around the world to question the legitimacy of US goals and activities in Iraq."[3] Bartone concluded, "Some analysts believe this event marked the turning point in the war, after which Iraqi and world opinion shifted substantially against the United States."[4]

The actual physical abuse, while deplorable, was not a substantial event that impacted multitudes of people in the physical domain. There were relatively few detainees, none of which was a high value individual. The "far-reaching consequences" were in the cognitive domain. Even in hindsight, it is not always the abuse that is talked about as the catastrophic event to US interests--it is the global broadcast of the photos that created international shockwaves. Bartone isolates the event where "photographs appeared in US news media."[5] The New York Times editorial staff describes the scandal

[3] Paul T. Bartone, *Preventing Prisoner Abuse: Leadership Lessons of Abu Ghraib* (Ethics & Behavior, 20(2), 161-173 (Taylor & Francis Group, LLC, 2010).

[4] Ibid., 165.

[5] Ibid., 161.

as “photos of Army Soldiers abusing detainees at the Abu Ghraib prison.”[6] It is not the physical abuse or the physical photos, it is the sentiment they conveyed to the world that was far outside the norms of acceptable behavior and created a “jerk.”

Perceived through the lens of mathematical understanding, the measures taken to remediate “jerk” behavior are strikingly similar in designing mechanical systems or in developing defense policy. Measures taken to ensure the acceptable norms of behavior are established and understood by the entire apparatus. Soldiers are trained repeatedly in rules of engagement, regulations are strictly enforced, and lessons learned modified and incorporated into routine activities. The military machine is well-tuned to the acceptable levels of “jerk” behavior. Yet, jerks still happen and will continue to happen. The physics are well understood, but the chemistry, both literally and figuratively, which makes an individual choose to act outside the norms is not. The defense establishment would be well served to continue to refine its parameters of acceptable jerks, to decrease response time to the behavior of jerks, and continue to seek greater precision in the chemistry of abnormal behavior. These are all well-worn platitudes of the art of war; however, it is not art, but calculus. The recommendations are lessons learned from trial and error; underestimating and overestimating the function until it is just about right.

Two additional recommendations can be gleaned by recognizing patterns instead of repeating the continual process of over and under. First, speed in correcting jerks must be maximized. To minimize response time (thereby maximizing speed), automation and decentralization are key. Human intervention in the system will still be required for the foreseeable future; however, automated tools can rapidly shape the decision-making

[6] New York Times Editorial, January 14, 2012, “Self-Inflicted Wound,” Section A; Column 0, Editorial Desk, 20.

criteria. Collective sentiment can be rapidly aggregated and analyzed with nominal human intervention.[7] Well-established strategic communications messages with decentralized execution authority will allow the jerk to be mitigated at the lowest level possible. With the combination of a rapidly aggregated assessment of the decision-making environment and decentralized execution authority, jerks will be decisively mitigated, giving the strategic apparatus a greater chance of avoiding catastrophe. Strategic messaging is not art, it is calculus.

Center of Gravity: Applied Integrals

One of the most talked about concepts inherited from Clausewitz by the military establishment is the concept of center of gravity. In physics, the center of mass is a point in a plane or volume where the entire mass of the object is effectively balanced. It is the singular point where the sum of an infinite number of mass points offset so that the moment about the axis is effectively null. The center of mass can be used as a singular point representing the mass of the entire object, and in a force field where the force in question is gravity, center of gravity and center of mass are equivalent.

In doctrine, center of gravity is defined as "the source of power that provides moral or physical strength, freedom of action, or will to act."[8] The doctrinal definition clearly confuses physical metaphor, using physical terms "strength" and "power" within the definition of a mass concept. Clausewitz, at least in the Paret translation, argued that

[7]Facebook, http://www.facebook.com/notes/us-politics-on-facebook/politico-facebook-team-up-to-measure-gop-candidate-buzz/10150461091205882. During the 2012 US election cycle, political think tank Politico teamed with facebook to collect and aggregate sentiment about presidential candidates. The algorithm identifies each time a candidate's name is used and evaluates the words associated with the post to determine negative or positive context. Similar tools are used in other social media, including Twitter. This type of automated data collection and analysis still requires a human in the decision cycle, but can vastly improve the speed of problem recognition through social feedback.

[8] Joint Staff, *Joint Operations Planning*, GL6.

"the center of gravity is always found where the mass is concentrated most densely" and concluded that, "in war as in the world of inanimate matter the effect produced on a center of gravity is determined and limited by the cohesion of the parts."[9] Clausewitz seems to have understood Newtonian mechanics in metaphor better than today's doctrine.

The debate over the true meaning of Clausewitz's metaphor will be left to the myriad volumes dedicated to said argument. With the operational calculus, hopefully the reader understands center of gravity in a novel way, perhaps even in the way originally intended by Clausewitz. Center of gravity is a function of area--it is dependent upon the mass distribution and the area across which it is distributed. If the density of an object is uniform, implying that mass is proportionally distributed across the area, then center of gravity is completely independent of mass and simply a matter of finding the area in question. However, as shown above, the area problem is only simple in linear environments. If the mass is not distributed evenly, the center of gravity becomes a function of area and density, a much more complicated process.

It does not appear that anything novel has been introduced in the center of gravity paragraphs above; however, looking at the same data in different ways, as Kuhn prescribes, changes its appearance. First, if center of gravity is a function of area and mass, it means that there are an infinite number of centers of gravity. Centers of gravity depend on how you define your area of operations, and how much mass is present in that area. It follows, then, that there should be little debate about a singular center of gravity. Yes, if the area is looked at as an entire theater, then there can be seen a single center of gravity. But, if the area is viewed in multiple subordinate areas of operation, such as

[9] Clausewitz, *On War,* 485-486.

regional commands within a theater, then the regional commander could legitimately define a center of gravity for his area of operations.[10]

Second, a center of gravity is the center of an area seen as a singular snapshot of time. If the area changes, such as when the area under hostile control is shrunk, then the center of gravity changes. Likewise, as a function of mass, when the mass within a given area changes, the center of gravity changes. For example, if a gifted general is seen as the center of gravity, when that general is neutralized or killed, it does not mean there is no longer a center of gravity, it has merely shifted to a new leader or other entity. It is a dynamic concept, just like everything else in war. While attempting to anticipate too far into the future will lead to mechanistic nightmares and contentious control debates like those surrounding Effects Based Operations (EBO), deliberate thought should be given to a shifting center of gravity in a dynamic environment.

Last, and perhaps most importantly, the area problem tells us that center of gravity must be a bottom up approach. Estimating the mass distribution of an expanse as broad and complex as a theater of operations is, for all intents and purposes, impossible; the distribution is far from uniform. Therefore, in order to reduce the density and area problem to a single function, one needs to find another way to eliminate the need to consider mass in the calculation. Mass, in this sense, is a concentration of capability or capacity in any of the Political, Military, Economic, Social, Information, or Infrastructure (PMESII) spheres.

One method to alleviate the need to understand fully the intricate relationships that have caused the evolution of creation and destruction within a system is to evaluate

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[10] Clausewitz, *On War,* 595-597. For more information see the discusison by Clausewitz of different centers of gravity in Spain and Russia.

the system at face value. To be explicitly clear, this is not an endorsement of a flippant view of the environment. On the contrary, this is an acknowledgement that in the real world the physics and the calculus change too quickly to grasp the true nature of the environment and any presumptions of understanding normally lead to disaster. There will always remain a need to “educate the intuition,” but there also must be an acceptance that complete precision is impossible. While complete precision is impossible, better precision is not.

At face value, the arrangement of PMESII capabilities can be seen as the critical enemy capabilities arranged in space and time. Normally, today’s intelligence is fairly accurate at estimating surface details such as the disposition of enemy forces or key population centers. The depth of relationships is less understood–the evolutionary cause and effect within an environment that determines things like intent or what happens next. In a traditional center of gravity analysis, the PMESII relationships are evaluated from a top-down approach for linkages, which should in turn identify a center of gravity. An alternative is to approach the problem from the bottom up just like any other area problem. If friendly capabilities are arranged to mirror enemy arrangement, the friendly and adversarial centers of gravity will also align, without a reliance on complete precision of knowledge. Capabilities can be aligned as “like” elements, or as capabilities intended to defeat or counter the enemy capability. The greater the number of capabilities aligned, the more precision that is gained in defining center of gravity.

For example, in 2003 the initial invasion of Iraq focused on Baghdad as the Iraqi center of gravity. In the rush to Baghdad, many mass elements were bypassed in the belief that if the center of mass was destroyed or neutralized, enemy resistance would implode. To some extent, that assumption was accurate. The Iraqi Army elements crumbled in the command and control void and the will to resist was minimal. However, many mass elements were left behind, and although the mass elements were static, they posed the potential to do significant harm if excited into motion once again. Specifically, hundreds of cache sites were ignored and left unattended in the rush to Baghdad. Those weapons caches became the mass to the force of the insurgency. Saddam-era artillery and mortar shells were the weapon of choice until the stocks were depleted in 2005-2006. Those weapons denied the coalition decision space in a secure environment to attend to the transition to civil control. If the concept of a strategic center of gravity were analyzed from the bottom up, it is likely that friendly capabilities would have been assigned to disparate mass elements throughout the country. Infrastructure assets would have been aligned to high-density infrastructure areas, information operations would have been distinctly divided to target specific disparate elements, and economic resources would have been applied to a broad array of targets rather than a few critical nodes. These distinct mass elements would have been countered with appropriate mass, and force, to prevent the mass from being accelerated in a negative direction in the future.

Figure A-1 shows the PMESII environment, and although this is a three-dimensional space, it is still a single instant in time isolated from change. There is no loop, or cyclical process. All PMESII elements are a subset of the same volume at the same time. In the traditional PMESII analysis, the linkages are identified and evaluated to highlight a single center of gravity.[11] In a bottom-up, integrated approach, like elements (or defeat elements) are aligned within each domain to match enemy

[11] See Joint Staff, Joint JP 5-0, Chapter IV for doctrinal Center of Gravity methodology.

capabilities. Center of Gravity is essentially null and void, because if your elements are aligned in space with appropriate mass to mirror the enemy, your center of gravity will also align, and with greater mass. The more resources aligned, the greater the precision. Additionally, conservation of forces is maximized since a clumsy application of overwhelming force at a few key points is avoided. Likewise, if your own capabilities are distributed in a manner similar to the enemy, it will induce a greater understanding of the relationships between nodes.[12]

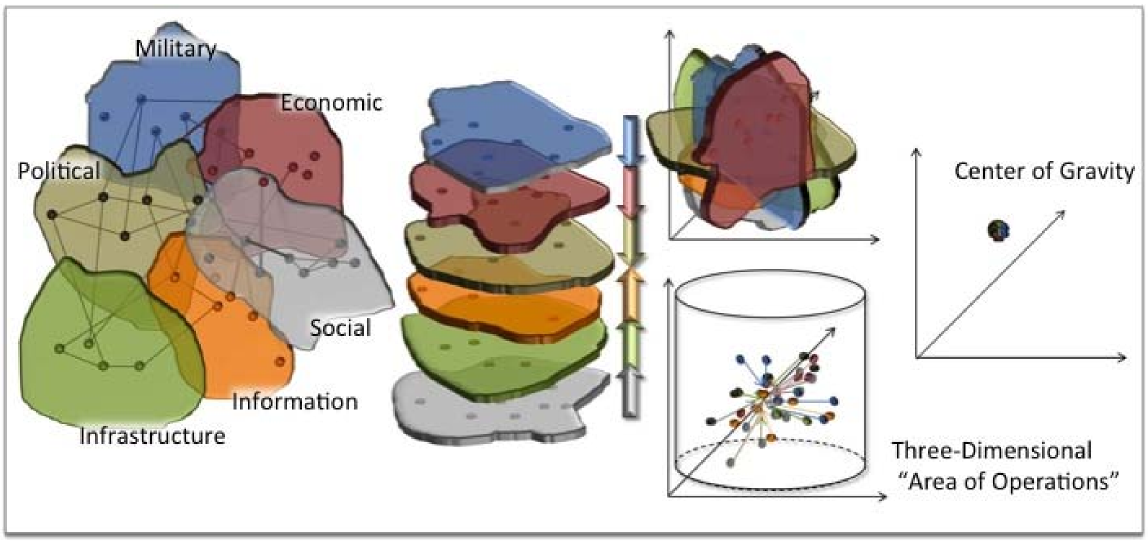

Figure A-1: Center of Gravity

While it may be difficult to discern why a bottom-up approach to Center of Gravity is a product of nonlinear thinking, rest assured that it is. Using calculus to solve center of mass problems in physics is an application of the integral calculus. The center of gravity is the sum at a single instant in time of an infinite number of mass moments

[12] Antulio Echevarria II, *Clausewitz's Center of Gravity: Changing our Warfighting Doctrine—Again!* (Carlisle, PA: US Army Strategic Studies Institute, 2002), http://www.au.af.mil/au/awc/awcgate/ssi/gravity.pdf, (accessed February 29, 2012). Echevarria suggests holding more closely to the physical metaphor of a center of gravity, but does not explore physics using the analytical method of calculus.

within a given area.[13] It was shown in Chapter 5 that the area bounded by a nonlinear function is equal to the integration of that function. So the sum of an infinite number of physical mass moments is found using the methodology of the integral calculus. Since it is nearly impossible to fully understand the array of enemy capabilities at any given instant, the mass distribution cannot be known with certainty. The solution to the integral problem then is finding a way to eliminate the need to understand the mass distribution completely. The only practical way to do that is to align friendly capabilities to enemy capabilities, rather than focus concentrated efforts at a few points. Moreover, as Echevarria puts forth, "A CoG is, therefore, *not* a source of strength, but a factor of balance."[14] As the enemy's balance changes with time, the friendly center of balance will mirror the changes as forces interact instead of remaining focused on a static, predetermined point. Center of gravity analysis in a dynamic, complex environment requires calculus, not art.

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[13] Stewart, *Single Variable Calculus,* 600. The Law of the Lever, discovered by Archimedes, states that "where two masses m_1 and m_2 are attached to a rod of negligible mass on opposite sides of a fulcrum and at a distance d_1 and d_2 from the fulcrum, the rod will balance if $m_1d_1=m_2d_2$." The mass times the distance is a called a moment. The sum of all the moments is called the "moment of the system about the origin." When the moment of the system is equal to zero, then the origin is the Center of Gravity. The same applies in multiple dimensions: the center of gravity is the point where sum of all mass moments is equal to zero.

[14] Echevarria II, *Clausewitz's Center of Gravity,* 6.

APPENDIX B: THE PANACEA OF OPERATIONAL ART

This appendix provides descriptions and discussions of operational art directly from Joint doctrine. Many observations on operational art are repeated throughout doctrine; however, in this Appendix observations are noted only the first time they appear in doctrine.

Joint Publication 3-0: Joint Operations, 2011 Edition

- *Operational art* governs the deployment of forces and the arrangement of operations to achieve military operational and strategic objectives (II-4).
- *Operational art* mitigate(s) the challenges of complexity and uncertainty (II-4).
- *Operational art* Supports the effective exercise of command by enabling a broad perspective that deepens understanding and visualization (II-4).
- Commanders, through *operational art*, seek innovative, adaptive options to solve complex problems (II-4).
- *Operational art* integrates ends, ways, and means, while accounting for risk, across the levels of war (II-4).
- *Operational art* determine(s) how, when, where, and for what purpose major forces will be employed and . . . influence(s) the adversary's disposition before combat (I-14).
- Applies to all aspects of joint operations (xii).

Joint Publication 5-0: Joint Operations Planning, 2011 Edition

- Commanders who are skilled in the use of *operational art* provide the vision that links tactical actions to strategic objectives (III-1).
- Through *operational art*, commanders link ends, ways, and means to achieve the desired end state (III-1).
- *Operational art* promotes unified action by helping commanders and staffs understand how to facilitate the integration of other agencies and multinational partners (III-1).
- *Operational art*, the creative thinking used to design strategies, campaigns, and major operations and to organize and employ military force, allows commanders to better understand the challenges facing them and to conceptualize an approach for achieving their strategic objectives (xvi).

Joint Publication 3-0: Joint Operations, 2006 Edition

- Is the thought process commanders use to visualize how best to efficiently and effectively employ military capabilities to accomplish their mission (IV-3).
- Promotes unified action (IV-3).

- Helps the JFC overcome the ambiguity and uncertainty of a complex operational environment (IV-3).
- Governs the commitment to or withdrawal from a joint operation (IV-3).
- Governs the arrangement of battles and major operations to achieve military operational and strategic objectives (IV-3).
- Is the manifestation of informed vision and creativity (IV-3).
- The essence of operational art lies in being able to produce the right combination of effects in time, space, and purpose (IV-12).

Joint Publication 5-0: Joint Operations Planning, 2006 Edition

- *Operational art* helps the JFC overcome the ambiguity and uncertainty of a complex operational environment (IV-1).
- *Operational art* requires broad vision and the ability to anticipate
- In applying *operational art,* the JFC draws on judgment, perception, experience, education, intelligence, boldness, and character to visualize the conditions necessary for success before committing forces.
- *Operational art* is the manifestation of informed vision and creativity
- *Operational art* emphasizes the importance of the creative imagination, judgment, experience, and skill of commanders and staff.

Joint Publication 3-0: Joint Operations, 2001 Edition

- *Operational art* helps commanders understand the conditions for victory before seeking battle, thus avoiding unnecessary battles (II-3).
- *Operational art* requires broad vision, the ability to anticipate, and effective joint, interagency, and multinational cooperation (II-3).
- *Operational art* looks not only at the employment of military forces and the threat but also at the arrangement of their efforts in time, space, and purpose (II-3).
- *Operational art* focuses on the fundamental methods and issues associated with the synchronization and integration of air, land, sea, space, and special operations forces (II-3).
- *Operational art* helps commanders use resources efficiently and effectively to achieve strategic objectives. (xii).
- *Operational art* provides a framework to assist commanders in ordering their thoughts when designing campaigns and major operations (xii).
- *Operational art* translates the joint force commander's strategy into operational design, and, ultimately, tactical action, by integrating the key activities of all levels of war (GL-14).
- *Operational art* is applied to plan and execute campaigns (III-4).
- Preserving the responsiveness of component capabilities is central to *operational art*. (III-14).
- Leverage is the centerpiece of joint *operational art*. JFCs gain decisive advantage over the adversary through leverage (III-14).
- *Operational art* form(s) the basis for plans and orders and set(s) the conditions for successful battle (III-25).

- *Operational art* [helps commanders in] knowing when to terminate military operations and how to preserve achieved advantages (III-24).
- The essence of *operational art* lies in being able to mass effects against the adversary's sources of power in order to destroy or neutralize them. (III-22).

Joint Publication 3-0: Joint Operations, 1996 Edition

- Basing in the broadest sense is an indispensable foundation of joint *operational art* (III-16).
- Preserving the responsiveness of component capabilities is central to *operational art* (III-13).
- Knowing when to terminate military operations and how to preserve achieved advantages is a component of strategy and *operational art* (III-22).

APPENDIX C: SUPPORTING FIGURES

The figures presented in Appendix C support those presented throughout the text. These figures represent either a nonsymmetrical complement to a figure in the body of the thesis or present more dtail than was able to be previously shown.

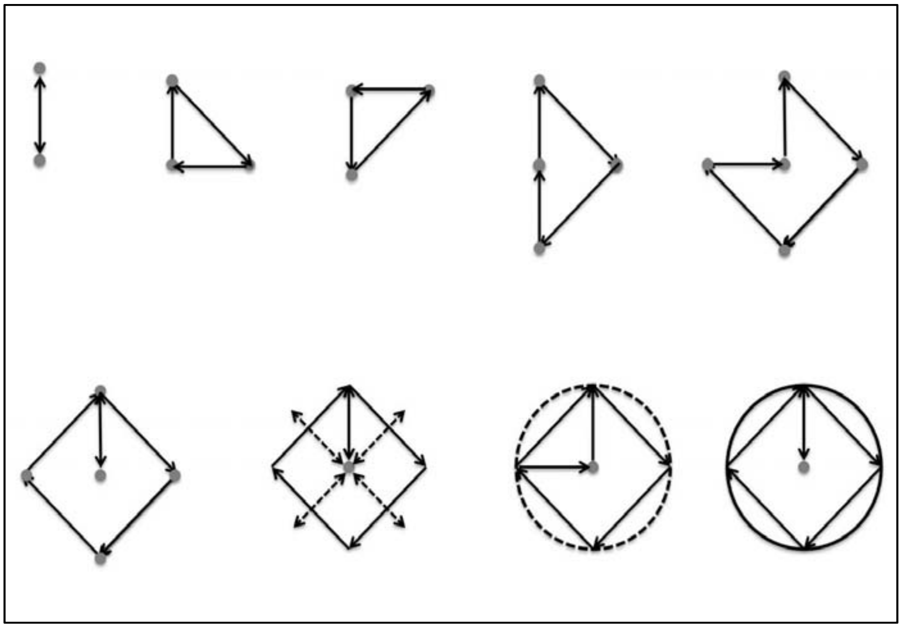

Figure C-1: Three Dimensional Arrangement of Knowledge

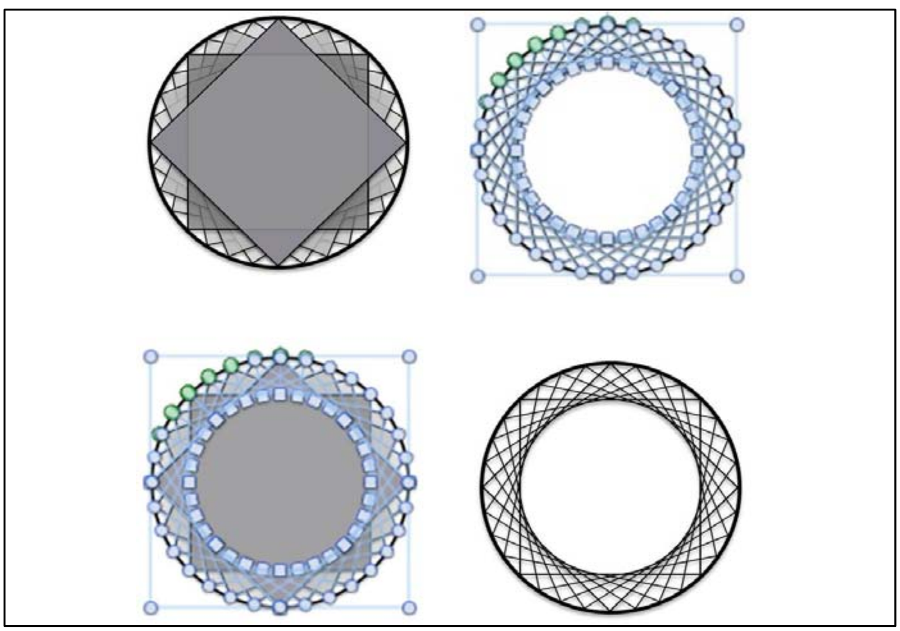

Figure C-2: Points and Lines of Knowledge

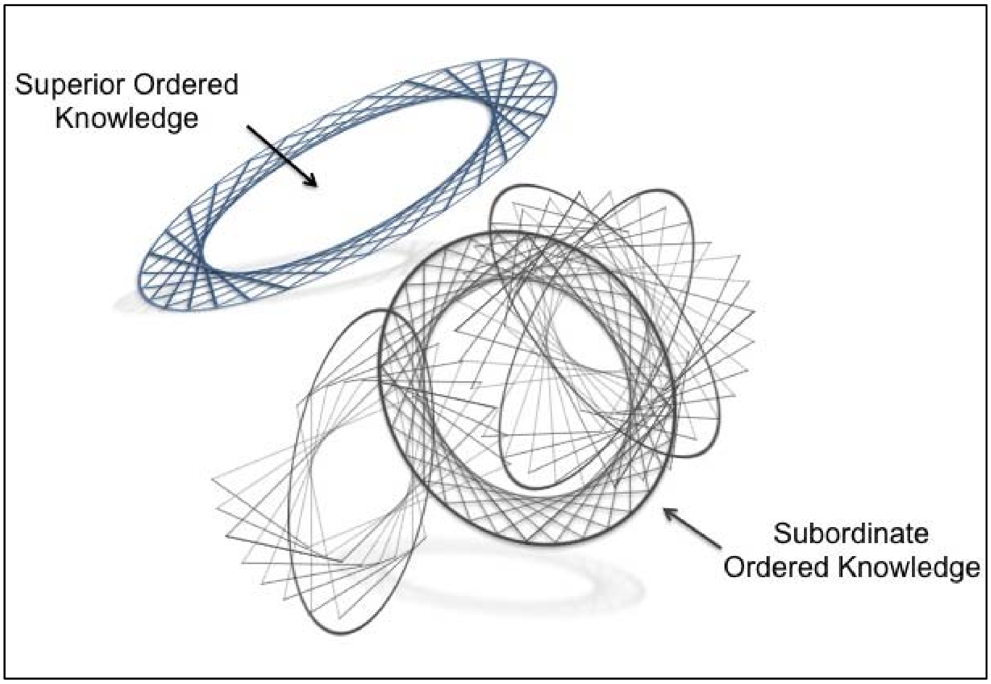

Figure C-3: Three-Dimensional Arrangement

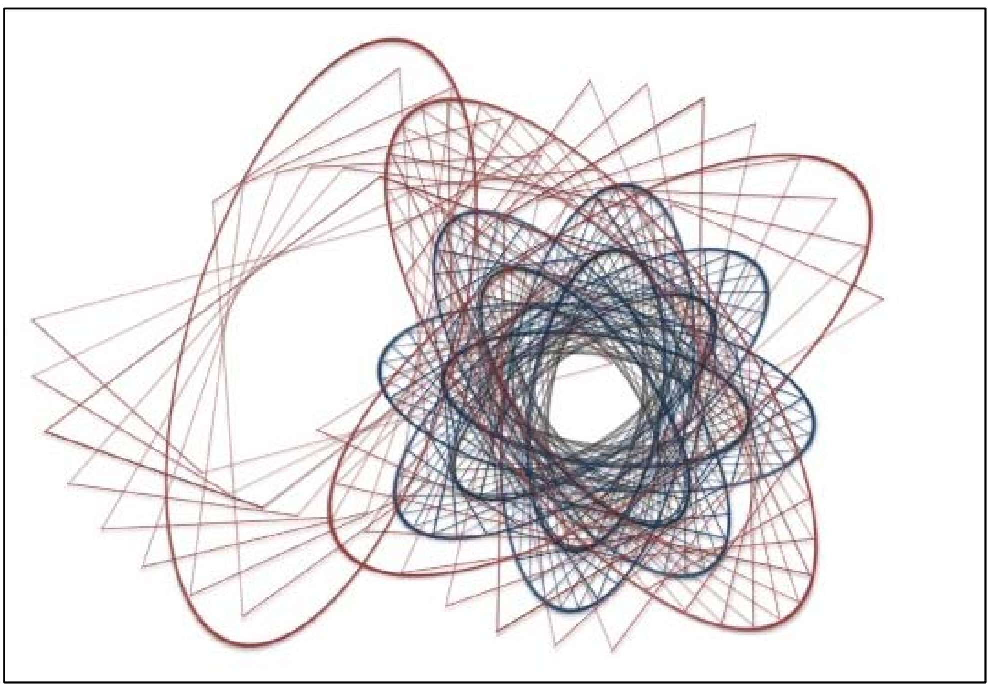

Figure C-4: Expanding Knowledge

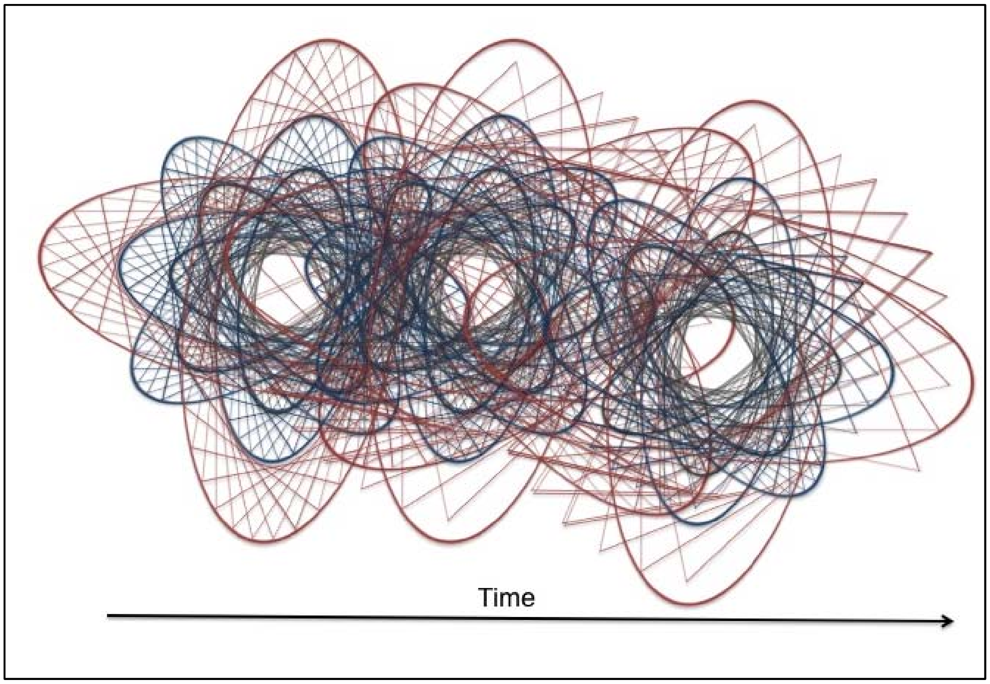

Figure C-5: Complex Change

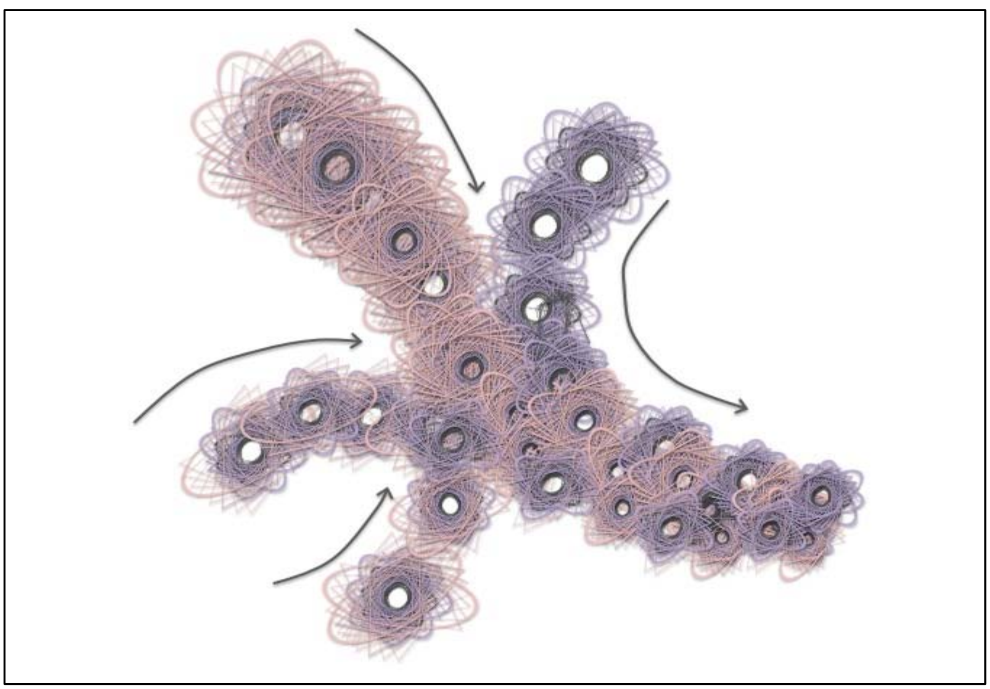

Figure C-6: Forming the Body of Knowledge

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